GEOLOGICAL SECTION FROM MOSCOW TO SIBERIA AND RETURN.

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The accompanying notes were made during the excursion to the Ourals which was arranged by the local committee for a certain number of Geologists before the business session of the Seventh International Geological Congress at St. Petersburg. In addition to the complete preparations for the expedition, carefully edited brochures of its different parts were printed by those Russian geologists who had devoted especial study to the districts. So far as the excursionists were concerned the section was necessarily one of inspection and verification of what had been done, rather than one of exploration for the establishment of new facts, and consequently, in a description like the following, the data secured in the years of long and patient investigation by the Geological Survey of Russia have been used so far as this epitome required them.

The lessons learned by the numerous, long and well planned excursions made in connection with the Congress, begin appropriately with the study of Moscow and its environs, for here many of the geological stages which form the most important points of orientation in the study of south-eastern and middle Russia are well developed and have been thoroughly investigated by numerous geologists.

In general terms Moscow is a city of very large area occupying a number of hills from 400 to 500 ft. above the average water level, which latter, at the southern boundary, is 348 ft. above the ocean. The hills are cut out of the boulder clay and morainic sand, the Cretacic, the Jura-Cretacic, (or Volgian), and the Jurassic down to the middle Carbonic (or Muscovian), on which the latter rests; by the Moskowa, the Yaouza, the Néglinnaia and their little tributaries. The lowest Mesozoic rocks overlying the Carbonic are of Middle Callovian age, and in the eastern part, of the government of Moscow they rest on the upper Carbonic rocks, chemically more altered than the Muscovian which form "the rocky base on which the ancient capital is built." [See Livret Guide, I.]. Borings undertaken to find artesian water in the Devonic have revealed

the following measured section from the summit of one of the hills 473 ft. above water level.

	Feet.
Argilo-arenaceous Quaternary and Mesozoic, ...	70
Middle Carbonic (Muscovian) limestones, ...	592
Lower Carbonic limestones, ...	243
Coal bearing Argilo-arenaceous stage of the same horizon,	161
Devonic limestones and Marls, ...	438
Total, ...	1504

The bottom of the bore hole was left in the horizon last mentioned.

Briefly stated the middle Carbonic or Muscovian of the vicinity of Moscow is typical of this stage, containing many fossil forms of which half are identical with those found in lower beds of the Carbonic of western Europe, while others have been found for the first time in the Muscovian.

The Jurassic fauna is practically in perfect accord with that of western Europe, except that the Sequanian is not suspectible of differentiation and the Kimmeridgian is petrographically and stratigraphically confounded with the overlying Volgian.

On the question of the Volgian appears the first of several subjects of debate among the Russian geologists. The author of the brochure (L. G., I.) M. Nikitin thus defines the Volgian to which he gave the name:—

"The Volgian comprises all those deposits in central and northern Russia which are found between the beds of the Kimmeridgian of *Hoplites eudoxus* and those of the middle Neocomian, lower part of the upper Neocomian (Hauterivian) stage containing *Olcostephanus versicolor*." The author, while admitting the possibility that in many parts of Russia where the Volgian is represented by only a portion of its beds, the explanation may be found in the non-deposition or subsequent erosion of the missing parts, inclines to the opinion that so far as the vicinity of Moscow is concerned the apparent absence of Kimmeridgian is caused by the insufficient preservation of fossils, while the absence of the upper Volgian and of the middle Neocomian is to be attributed to the first two mentioned reasons.

These measures have been principally studied by Nikitin, Bogoslovsky and Pavlov of the University of Moscow.

Nikitin thinks that the Volgian group possesses a type of its own not recognized in the classification and terminologies of western

Europe, and prefers not to attempt its division between the upper Jurassic and the lower Cretacic until a great deal more work has been accomplished. Bogoslovsky terminates the upper Volgian at the horizon *Olcostephanus nodiger* which he considers the uppermost limit of Jurassic as that of *Hoplites Rjasanensis* is of the Neocomian and the bed *Olc. polyptychus* and *Olc. hoplitoides* the principal lower bed of the Neocomian.

Pavlov, while accepting the succession of the others, classes the entire Volgian group with the Jurassic, adding also a part of the Neocomian of western Europe.

With this preliminary glance at the formations in the vicinity of Moscow, we were prepared to enter upon the first of the great excursions, or that to the Ourals. The start was S. E. down the Moskwa on the Moscow-Riazan Railway, which runs over the lower arenaceous member of the boulder clay or the eluvion which was laid down upon it after the erosion of the morainic upper part. To Bykowa the cuts and pits show white stratified sands belonging to the upper Volgian. S. E. of Lioubertzy the surface of the hills is said to be formed of sands and sandstones, partially modified to quartzite containing ammonites typical of the zone of *Olcostephanus nodiger* and *Oxynoticeras subclypeiforme.* The lower Volgian is found at Miatchkowo resting on gray and black stratified clays with intercalations of dark brown argillaceous, combustible schists, 28 to 33 ft. in thickness, corresponding in general to the Oxfordian and Sequanian. M. Nikitin was led to conclude from a study of this series that at least in central Russia there exists an intimate connection between the beds of *Cardioceras cordatum* and those of *C. alternans,* which appears not only in the continuation of the greater part of the conchifers and gasteropods from one horizon to the other, but also in the gradual change and passage of some forms of ammonites and other species [L. G., II.]. This conclusion is of the greatest importance to the student of the Jurassic in Central Russia.

Pursuing the route through the government of Riazan along the river Pronia, the lower Volgian and upper Jurassic representatives are seen to disappear so that the horizon *Hoplites Rjasanensis* rests successively, first on the Oxfordian and later, near the town of Skopine, on the Callovian. The Carbonic limestones also show gradually descending outcrops from the lower stages of the Muscovian, through the different levels of the lower limestones of

Productus giganteus and finally to the lower coal in the neighborhood of Riajsk and Skopine. The quaternary boulder clay of this region contains large blocks of crystalline and quartzitic rocks from Finland. All these quaternary deposits of this region are covered by a dark brown or black soil, which the Russian investigators agree to divide into two classes. 1st. the "tschernozem" properly so-called, which is dark brown or black, 0·5 meter or more in thickness, rich in humus, lime and zeolites, formed in place by the alteration of various superficial deposits, etc.

2. Forest earth, also dark brown or black, but of different physico-chemical constitution.

It may be true, however, that the tschernozem of the steppes when covered by forests is gradually transformed into forest earth. These two kinds of soil and the resulting steppe and forest alternate in the region between the Pronia and the Volga. The line of route from Riajsk through Pensa to the neighborhood of Syzran follows the great trans-Siberian railway over upper Cretacic and lower Tertiary steppes of moderate glacial interest, and considerable monotony, but at the latter place there is an abrupt change.

About 760 km. from Moscow by railway, or 1,400 km. from the head-waters of the Volga not far from St. Petersburg, a sudden change in the landscape and surroundings on close approach to the great river indicates that some special forces have been at work in this neighborhood. In the first place, the Volga, after pursuing a generally south direction from Kazan, abruptly turns to the east for about sixty kilometers while skirting the north flank of the Jegouli Mountains, but here breaking through them perpendicular to the axis of their prolongation, and leaving a large enough mass on the left bank to act as one of the two posts of the gates of Samara, it returns in a direction parallel and opposite to that by which it had come, and finally resumes its southerly course with some slight westing toward the Caspian Sea, distant about 1,000 kilometers. It appears that a gentle anticlinal, with an axis running northerly, and recognized further to the north in the tilted Permian limestones of the right bank of the Volga, has suffered a local dislocation resulting in a fault cutting through it almost at right angles, and bent in the west flank. The fault passes along the north side of the peninsula, which is called Samarskaia Louka, after the large city opposite its extreme point. Both sides of this fault-line the measures dip S.S.E., but the north side has been depressed, while that to the south

has been elevated. In the depression of the river Syzran the deposits of the Caspian have been laid down. Following the Syzran River down stream over its easterly course to join the Volga, one sees to the south of the fault the successive appearance of ever older measures, from the upper through the lower Cretacic, the Volgian, the Callovian, and, finally, near the town of Syzran, the upper Carbonic. The railway runs along the heights commanding the town of Syzran, which consist of Jurassic and Volgian, but as soon as it has passed that town it descends and runs along the right bank of the Volga, on the terrace of these formations resting on the Carbonic limestone, to the village of Batraki, south of the Samarskaia Louka. Thence a short distance down the Volga ($\pm$ 15 km.) one reaches Kashpour. On the hill of this name one sees in succession downward from the top various horizons of the Cretacic, the Volgian, and finally the river deposits. Above Batraki, a less distance, one comes to the great bridge of the trans-Siberian railway across the Volga, 1,485 meters long, on twelve piers, and estimated at 150 ft. above the river. At the abutments the Carbonic deposits are compact limestones more or less dolomitic, containing *Fusulina* and saturated with asphalt as at Syzran.

The orographic feature of the approach to Syzran is the elevation caused by the fault passing north of the Samarskaia Louka, at the great bend of the Volga. The part of this elevation at and west of Syzran is called the Syzran Mountains, that of the nucleus of the peninsula the Jegouli, and on the opposite or left bank of the river, the Mountains of Sok. The main mass of these mountains is composed of Permian-measures; but in the neighborhood of Samara, as at Samarskaia Louka, deposits with shells of *Cardium*, *Corbicula* and *Hydrobia* give the impression that these are the remains of the the Caspian basin. The terrace clays are distinctly laid on the Permian, but the Caspian sediments which are only of insignificant thickness, are found in detached islands, and may be seen far up on the heights of the Volga throughout the whole course from Kashpour. The upper beds of the Permian at Samara are compact limestones with intercalations and masses of gypsum and silex, which have made the construction of the railroad bed very difficult in places on account of the tendency to landslides. The lower Permian beds, oolitic in places, are rich in lamellibranchs, gasteropods and brachyopods characteristic of the Permian.

Below, there is a cavernous brecciform limestone formed of fragments of limestone cemented together by calcareous matter, but without fossils. It is about 83 feet thick, occurs about 4 kilom. up the Volga from Samara, and forms a large part of the upper part of the Mountains of Sok. Some kilometers before reaching the confluence of the Volga and Sok the Carbonic limestone shows itself beneath the brecciated limestone in the sandy beds as in the mountains of Jegouli. The upper horizon shows *Schwagerina* limestone. Separated from the Sok Mountains by the valley of that name is the mountain or hill called Tzarev-Kourgan (Hill of the Tsar). It shows in descending order from the top: Limestone with *Fusulina longissima* and other Fusulinas, *Spiriferina Taranæ*, and *Productus Villiersi*.

(*d*) Limestone with *Bellerophon*, large, as yet undetermined *Spirifers, Nautilus, Orthoceras.*

(*c*) Dolomites with *Productus Cora.*

(*b*) Limestone of *Productus scabriculus, Camarophoria crumena, Meekella eximia.*

(*a*) Limestone of corals and bryozoans.

The Hill of the Tsar is thus formed by the same limestones as those constituting the greater part of the Jegouli, and like that of the fauna of gshélien age near Moscow.

The long distance from Samara to Oufa over the trans-Volgian steppes is over the Permo-Trias and the Permian. The modelling of the country is so strikingly like that of the bad lands of South Dakota and other parts of the western United States that no one who had seen both could fail to be struck by the resemblance. The geology would seem to be of the simplest, viz.: the very gradual succession of continually lower horizons from the Volga to the Ourals.

But we come unexpectedly here upon another burning question which divides the geologists of the official survey and others from Stuckenburg, Kratov, Netchatev, Amalitzky and still others. The Geological Survey sees in these beds which it marks P T., and which lie between the Permian and Trias, a series of transitional deposits not closely analogous to those in similar horizons in central Europe, and proposes for them provisionally the name Tartarian. The opponents of this view class all the upper beds of the iridescent marls as Permian. The Russian Survey recognizes two series of red and iridescent rocks. The first it calls the Tartarian, which

caps the beds of Zechstein fauna, and the other lies below the Zechstein, corresponding in part with its lowest horizons.

As approach is made to Oufa one after the other of the distinguishing beds in the two formations rises slowly and loses itself farther east on the tops of the nearest hills. The gray group of schistose limestone and marls intercalated with friable sandstone marking next to the uppermost member of the Permian, recognized by the Russian Survey, shows itself for the last time on the summit of Yarych-Taou, the last of the conical mountains of erosion along the Dioma. The appearance of a red group in the sections near Oufa has caused many geologists to ascribe this horizon to the Tartarian, which the geologists of the survey hold to be an error, maintaining that the ravines and sections establish beyond doubt that the measures increase in age as one goes eastward.

Oufa may be properly said to lie on the line which marks the foot of the Ourals, because at about this distance from the axis of the Oural chain the streams having broken through the west flanking foot hills of the main chain take the final courses to fulfil their ultimate destiny of irrigating and fructifying the trans-Volgian steppes.

The Permian plateau on which Oufa stands is cut by three rivers: the Oufa, the Sim, and the Biéleia, into three elevated plateaux separated by deep and rich valleys. The immediate neighborhood of Oufa has not furnished distinctive fossils, but the sections along the Biéleia and its affluents have convinced the geological surveyors that the upper part of the section at Oufa corresponds with the lower Permian red bed which is capped by the gray arenaceous Zechstein bed, richly furnished with fossils that can be seen in the sections of Slak, the mountains Yarych-Taou, etc., between Samara and Oufa. The lower gypsiferous and calco-gypsiferous bed at the base of the Oufa section can be seen to have intimate relations with the gray, compact, tile-like limestones, and dolomites, and the cavernous, spotted brecciform limestones containing many casts of *Bellerophon*, remains of *Productus* and *Orthoceras*, accompanied by *Schizodus truncatus*, *Astarte Permo-Carbonico*, *Macrodium kingianum*, and corresponds to the lower Zechstein of southern and central Russia, situated below the lowest bed of Permian red. [See L. G., III.]

As an aid in understanding the orography of the western half of the Ourals (from which the eastern half is entirely different) let it be

borne in mind that the westward flowing streams usually have their origin in extensive marshes and bogs lying in the elevated parts of the longitudinal valleys, and covering many square wersts[1] or kilometers. The first part of their course, or that more or less on the line of the meridian north or south, is usually rapid and tumultuous. In their middle course they take a sudden change in a direction at right angles to their final course and descending with the same rapidity cut through gorges ten wersts or so in length with abrupt and sometimes vertical walls 100 meters and more in height.

Having passed the westernmost rocky barrier the rivers flow sluggishly through large alluvial valleys in which rock in place is rarely seen, and the affluents of the larger streams are few and small. These valleys are filled with the remains of ancient river and lake beds, and show distinctly alluvial terraces.

Having brought the section to the lower Permian spotted limestones and dolomites the further journey east reveals a series to which the name Permo-Carbonic has been given.[2]

This band separating the two groups is divided into an upper or calcareo-dolomitic, and a lower member called the horizon of Artinsk. This latter contains sandstones, limestones, marls and various schists. Karpinsky, Kratow and Tschernischew have shown that it is characterized by original ammonitides of great interest since the discovery of similar forms at Darvas in Sicily, in Texas, and other places. It contains brachiopods also, of which the study has established the connection of the different subdivisions of the *Productus* limestone of the salt range with the paleozoic deposits of the Oural.

The Carbonic of the South Oural consists exclusively of three sections of limestones each, and especially the uppermost, characterized by an abundant fauna.

The Devonic is also represented here in all of its three sections, of which the lower is much the most interesting, both because to it is attributed the rocks forming the highest chains of the Ourals, and because it is therefore the real crux in the geology of these mountains which is destined to give rise to a voluminous literature, and remain a moot point among geologists for many years to come. The middle division of the Devonic is also of interest as frequently containing a

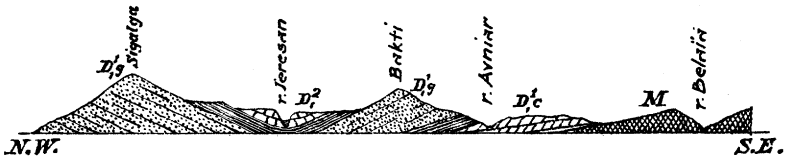
[1] Eleven kilometers are reckoned equal to ten wersts.

[2] It would have been more in conformity with usuge had the name been Carbono-Permian.

development of its limestones and marls in innumerable swellings or lumps of various sizes from a few inches to a few feet in diameter, which on examination prove to consist either of concentric cabbage-like layers, or of irregular foliations like the bent leaves of a book.

The immensely important conditions which follow from the acceptation of the Russian Survey's determination of the relations of the rocks forming the Oural-Taou, or main chain of the Oural, makes it desirable to consider it a little more attentively.

The Oural-Taou, or main chain, and water-divide of those mountains is formed of crystalline schistose rocks, which are in *intimate connection* with deposits of indisputable paleozoic age, and which themselves are nothing but modified paleozoic rocks. This is the terse summing up of the thesis [L. G., III, 12], and the argument is contained in the ideal section (ib., p. 11), in which the lower Devonic member is shown to be a quartzite lying in a synclinal between schists and limestones above and below; and the lower of these limestones is stated to contain no fossils by which its age can be definitely ascertained in the northern Oural region. But in the South Ourals it contains an extensive fauna described by Tschernischew.



Section from the Zigalga to the Avniar

(from Livret Guide III. p 11)

FIG. 1.

D_1^2 Limestone. Upper stage of the Lower Devonic.
D_1^1 g Quartzose sandstone and schists.
D_1^1 c Limestones.
M Metamorphic schists and quartzites.

The section representing the views of the Russian Geological Survey as to the structure of the Oural chain is seen in L. G., III, p. 11, and is thus described by M. Tschernischew:—

"The most instructive section of the lower Devonic of the south Ourals extends south of the line of railway, from the chain of

Zigalga to Avniar transversely to the direction of the Zigalga and of the Bakti and crossing the rivers Yourezan, Avniar, and Biéleia. This section shows the principal mass of the bed of quartzose sandstone D_1^1 g between two schistose beds of which the lower rests directly on the oldest limestones D_1^1 c of characteristic fauna. The predominant rock of the lower schistose bed is a black sericitic schist reflecting on its steel-gray surface, sometimes a silky lustre. Quite often is observed the passage of these schists into micaceous and chloritic varieties, very rich in magnetite and hematite. Taking up quartz these schists pass into micaceous and talcose quartzites. In places the black argillaceous schist shows inclusions of large pyrite crystals, and pseudomorphs of pyrite in limonite."

'This black schist is associated in the lower part of the bed D_1^1 g with a serecitic schist nearly of the same composition as the black, but poorer in carbonaceous matter and consequently of a lighter shade.'

'After a certain amount of practice it is easy to distinguish the lower schists, situated under the horizon of quartzites and sandstones, from the schists which surmount this horizon. The latter of very variable color, structure, and composition never have this reflexion on the plane surface but they pass also, though very rarely, and in exceptional cases, into chloritic and ottrelitic schists. Their color, sometimes banded, varies between dark gray almost black, yellowish, greenish, and reddish gray. Marly sandstone, marls, and limestones occupy a second rank in the bed D_1^1 g.'

'A series of rocks D_1^1 g separates, as we have said, two beds of limestone essentially different from a paleontological point of view. The upper limestones D_1^2 g of which the type is developed in the Yourézan valley encloses subordinate beds of argillaceous schists and marly sandstones. Their paleontological character is described in the paper, 'Die Fauna des unteren Devon am Westabhange des Ural,' by Th. Tschernischew. This horizon is especially characteristic by its abundance of *Leperditia Barboti*, small trilobites of the genus *Cyphaspis*, *Pentamerus fasciculatus*, *Pentamerus baschkiricus*, remains of conchifers *Conocardium crenatum*, *Buchiola sexcostata* and other forms.'

'The lower limestones D_1^1 c capped by the bed D_1^1 g and often found between metamorphic rocks (as in the upper course of the Biéleia), are distinguished by their lighter tints, and a marble structure. Their fauna described in the above work by Tschernis-

chew is distinguished by a great variety of forms; *i. e.*, numerous remains of ostracodes, cephalopods, *Platyceras*, representatives of *Hercynella* (*H. bohemica*), and peculiar conchifers (*Vlasta Dalila*)."

In the section this limestone apparently rests conformably on the group "M" of metamorphic schists and quartzites, which is thus assumed to be of lower Devonic origin.

The lower division of the Devonic is thus described (l. c., 10):

"It has great petrographic diversity. The varieties most developed include quartzose sandstone without feldspar, arkoses and conglomerates. These are the rocks that form the ridges of the most considerable parallel chains of the South Oural. In the eastern summits is observed a gradual transition from sandstone, arkoses and conglomerates, to compact quartzites, charged more or less with mica. The lower schist is a black sericitic schist, giving a steel gray sometimes silky reflexion on the surface. Frequently the passage of these schists to micaceous and chloritic varieties, very rich in magnetite and iron oxide, can be observed. Taking up quartz these schists pass into micaceous and talcose quartzites. In places the black argillaceous schist shows inclusions of large crystals of pyrite and pseudomorphs of pyrite in limonite. This black schist is associated in the lower part of the bed D_1^1 g with a sericitic schist nearly of the same composition as the black, but poorer in carbonaceous matter, and therefore of lighter color."[3]

"The rock most largely developed in the underlying group M is a mica schist composed of quartz and mica, to which is ordinarily joined a greater or less quantity of chlorite and magnetite. The element of greatest interest in these mica schists, and chloritic mica schists, is the orthose, which occurs in irregular and often broken fragments. Very often these are enclosed in grains of quartz or mica. Indications of the substitution of quartz and mica abound in the cleavage of these orthoses. Tourmaline, and in the neighborhood of Slatooust, garnets and staurotide are the most frequent inclusions in the mica schists."

"Besides these schists the crystalline region comprises M a series of argillo-schistose rocks which show the transition of typical phyllites into the clastic argillaceous schists of the lower Devonic. The massive rocks of M are represented only by granites and diabases. Among the granites can be distinguished the gneisso-granites and the coarsely crystalline porphyritic granites resembling what is called Rappakiwi from Finland, which is much used for building, and forms

[3] See preceding page.

the pillars of St. Isaak's as well as the parapet of the Neva within the city of St. Petersburg.

Such is the veriest skeleton outline of the facts of structure stated by M. Tschernischew in L. G., III, and which he illustrated by the nine days of excursions between Oufa and the crest or median line of the Ourals. A point of the greatest interest, but connected with the structure at the uppermost extremity of the scale must not be forgotten for it constitutes a lesson of the trip second in importance to no other. It is in effect that the explorations of the river terraces of the Biélaia leave no doubt of the relations between the upper terraces and the post pliocene deposits of the Caspian sea invasion. The conclusion is that these upper terraces belong to an epoch, when the Caspian Sea played the part of a dyke which brought about the raising of the level of the Kama, the Biéleia and their affluents with the consequent decrease of the rapidity of their currents and therefore of their erosive force. In proportion to the retreat of the Caspian sea, the erosive power of the rivers must have augmented, from which resulted the narrowing and deepening of these beds and the formation of terraces. This latitude is about that of the northernmost deposits, attributed to the former Caspian Sea, (57° North), while the southernmost similar formation ascribed to the action of the White or Northern Sea lies approximately on lat. 61° North, leaving 4° or about 440 kilometers (273 miles) in which the traces of neither sea have been found, but in their places the evidences of lacustrian remains filling the gap.

The route from Oufa was along the post pliocene terrace of the River Sim, to the upper Carbonic limestone mountain, Kyssy-Taou, containing *Schwagerina*, while on the left were the lower Permo-Carbonic deposits of Artinsk. Descending the mountain again to the terrace, this latter is followed to the station Ascha. Proceeding in general northeast beyond this the course is over upper Carbonic limestones. Just before reaching the mouth of the river Karagai-Elga, this formation suddenly gives place to the middle Devonic across a fault, visible on both banks of the Sim. A little below the confluence of the Chalcow and the Sim, one sees the cabbage structure of the upper division of the lower Devonic. Near the mouth of the Biarda the superposition of D_2^2 on D_2^1 is seen. Miniar is soon reached lying at the foot of a series of picturesque hills formed of D_2^1. The next undertaking was the

examination of the rocks from Miniar to Simskaia. The cliffs were made up (counting from the base) of lower Devonic limestones (D_2^1), the limestones and dolomites (D_2^2), the *Spirifer Archiaci* limestones (D_3), and the lower Carbonic limestones C_1. Below the Miniar works the D_2^2, limestones show in places the cabbage structure. About the mouth of the Kalosleika the lower Carbonic limestones crop out containing an abundance of foraminifera, (*Eudothyra parva, Fusulinella Struvii, Archœdiscus Karreri,* and fragments of *Productus striatus* and *Chonetes papilionacea.*) The borders of the lake of Simsk offer a classical section for the study of the deposits of Artinsk, and Carbonic sediments.

The journey was continued up the valley of the Eralka and down the valley of the river Berdiach, still in the deposits of Artinsk. At the (Baschkir) village of Yakhia the Carbonic limestones are again met.

These show themselves all along the route to Oust-Kataw, where the fossil remains are very abundant.

Between Oust-Kataw and Wiazowaia the same Devonic series is several times repeated. At Wiazowaia the railway was left and a section was made in droschkes to the mines of Bakal. The succession D, D_2^1, D_2^2, is thrice repeated between Wiazowaia and the village of Perwoukhina the highest crests being formed of the first named bed, which, two faults successively raise. It is in these three mountains Chouida, Irkouskan and Boulandikha, (all of lower Devonic), that the very rich iron ores of Bakal are found. They have been worked for a century and a half but as yet and for a long time in the future the work has been and will be done in open cuts. The variegated quartzites and quartzose schists are cut by dykes and massives of diabase.

The mineral masses of Hematite and Siderite are exclusively found in the middle member of the above series or the variegated schists where they are sometimes 40 meters and more in thickness. Besides this the minerals show themselves sometimes in pockets. A glance is sufficient to show the intimate connection between the dolomitic limestones and the mineral deposits. One can follow step by step the transition of the limestones into spathic iron and that into hematite. When the mines were first exploited only Hematite was found at a short distance from the surface, since then in proportion to the depth of the workings spathic iron has been found with passage into dolomitic limestone. The mines of Bakal and Satkinsk

were examined and the return to the railway was made at the station Souleia over Devonic measures.

From Souleia to Slatooust the upper divison of lower Devonic D_2^1 is passed over as well as D_1^1. Near the station Berdiaouch the dolomites D_2^2 are seen with thick dykes of porphyroid granite intercalated among them and resembling the Finland Rappakiwi. Between Berdiaouch and Toundouch the line pursues the horizon of the Devonic limestones and dolomites, showing frequently the foliated structure below described.

Finally a complex succession of rocks begins at the village of Medwediova containing limestones, schists and argillaceous and sericitic sandstones, mica schists, diabases, amphibolites and gneiss, all thrown into folds of high dip and penetrated by faults. The mutual relations of the massive rocks, crystalline schists and the quartzites of Ourenga and Kossotour are clearly seen in the sections near Slatooust. This town lies in a picturesque valley of the river Ai. The Kossotour and Ourenga heights which border it, on the north and south respectively are similarly composed and are parts of the same orographic unit.

Under the leadership of Mr. Tscherneschew, Kossotour was reached by a brisk walk through the woods from the station of Slatooust and sections were made along the river Ai, showing coarse grained mica schists and amphibolite, containing large Garnets, diabase, garnetiferous mica schists, diabase, mica schists, massive diabase containing an abundance of secondary products and strongly altered, mica schist of Biotite, Muscovite, Quartz, and Epidotes, enclosing large Garnets; diabase, mica schists with Almandine; amphibolite more or less schistose, and mica schists with small garnets.

A section in the railway cut near the station from southwest to northeast, showed a series of mica schists dipping $\pm$ southeast—65°. There are many inclusions of milk quartz and the bedding becomes thicker to the north-east, after the first 100 ft., but the general character of the rocks is comparatively uniform and resembles that of some American rocks, called by the late Dr. Hunt "Taconic." About 200 ft. from the commencement of the section is a mass of quartzite and further to the north-east again mica schists, followed by garnetiferous schist, the Garnets being large and round. To these succeed more mica schists, intercalated among which appeared other small outcrops of quartzite. The railway

cut is about 400 ft. long with two sigmoid curves. One hundred and fifty feet from the northeast end a very much decomposed grayish layer occurs containing Garnets, some of them flattened on the planes of bedding. About 75 ft. from the northeast extremity a mass of white quartz occupies a large space and penetrates to the surface of the cut above, embedded in the mica schist. Another mass of white quartz strikes across the railway, south 20° west, mica schists follow this to the end of the cutting.

The next object of study was the Bolchoi Taganai (or Great Taganai). There are three mountains called Taganai, viz: Bolchoi (or great), Srédny (or medium) and Maly (or small) north of Slatooust, which are connected together and with the Oural-Taou or main chain and water-divide by high plateaux. They are separated from the north flank of Kossotour by the valley of the river Bolchaia-Tessma.

All of these heights are composed similarly of a quartzite summit overlying a friable sandstone with kaolinized Feldspar, and this latter resting on garnetiferous mica schist with subordinated limestones. The dips being to the north-west, faults with a southeast hade repeat this succession, three times, the easternmost repetition, being the lowest but the most extensively developed and formed by the chain Oural-Taou. On the east side the heights are abrupt precipices, but on the west they are gently inclined and accessible.

The river Kiolim, which traverses the Ourals and forms part of the Siberian river system, descends this divide to the north, the river Tessma an affluent of the Si, taking its course to the south, where it ultimately joins the waters of the Caspian Sea. At the base of the Bolchoi-Taganai (called Otkliknoi) occur outcrops of diabases. The words of M. Tschernischew are herewith repeated. "*The detailed study of our section demonstrates that all the Taganais show the same succession of rocks rent by a series of faults. It is equally beyond doubt that the quartzites of the Taganais correspond completely with the quartzites and sandstones of the lower Devonic that we have already encountered on our trip to the mines of Bakal and environs. It results indubitably that the metamorphic rocks which support the quartzites of the Taganais are the same clastic modified rocks of the lower Devonic developed in the more western parts of the Ourals.*"

A study was made of the but little altered Devonic measures near the works of Koussinsk where there is an outcrop of dolomitic lime-

stone dipping to the southeast and constituting the "mountain" Silitour. In the neighborhood of Koussinsk also are interesting examples of the limestones with the foliated bosses often heretofore referred to. These limestones belong to the middle Devonic (horizons D_2^2 b with *Spirifer Anossofi*, and D_2^2 a with *Pentamerus bashkiricus*).

On July 30–(August 11), the train was run back from Slatooust on the road some 20 kilometers to the "platform" (flag station) Koussinskaja, and the excursionists were taken in droschkes twelve wersts south to an exploitation of a mine called Schichimskaja Gora. This was simply a cut in the face of the hill of 100 feet or more in width, exposing talc and chlorite slate cut by porphyritic diorite. Many minerals occur at this contact, which may be found described in L. G. IV, 3 +. Returning to the platform, we started after breakfast to the town and smelting works 14 wersts north of Koussinsk, where the pretty iron ornaments sold in Slatooust are made. The start was up a long ascent of the mountain Lipowaia. At a considerable hill called Silitour, just outside of the town, our examination was made of a contact between diabase and the lowest member of the middle Devonic limestone, where M. Tschernischew maintains there is alteration at only one of the two contact planes.

The ascent of the water-divide of the Oural, was accomplished in the train by crossing the Tessma and turning south, where a series of iron ore mines lying between the metamorphic rocks and the dolomitic limestones is passed. The mines are mostly abandoned. The limestones cover stratified deposits of hematite. The rocks are much dislocated, but maintain a general direction of N. 30° E. The dolomitic limestones correspond to limestones D_1^1 c of the upper part of the Biélaia and the mines of Bakal. On the east of the railroad the mica schists are cut by granites. In the two great zigzags made by the railroad in mounting the height, it traverses a development of garnet rocks analogous to those seen at Slatooust (Kossotour and Ourenga).

About 3 wersts from Ourjum station, which is almost on the divide, in the rocky crest of Alexandrovskaia Sopka, composed of the same quartzites, as those of the Bolchoi-Taganai, the highly inclined beds dip toward the European side of the Ourals. The Asiatic side is covered with detritus and blocks.

We have now arrived at the divide and seen all the rocky series which are displayed on its west side. These series starting from

Oufa may be resumed in the letters employed by the Russian Survey, as Permian (P), Permo-Carbonic (PC), Carbonic (C), Devonic (D), and finally the material which constitutes the divide called M, and thought by the official geologists to be metamorphosed Devonic.

It is supposed that the upper and lower black schists are part of D_1^1 g and that D_1^1 c and D_1^2 are conformable with them. The demonstration turns upon this. Beneath D_1^1 c come the schists and quartzites marked metamorphic. It does not clearly appear how the limestones are superposed on it, but unless M be altered Devonic, this is of minor importance. No one would dream of calling in question the accuracy of the Russian geologists who have proposed this structure, without weeks or months of hard and patient labor in the field. To do so would be to show an unpardonable ignorance of the difficulties of the problem and a poor recognition of the accurate work which these gentlemen have accomplished. But they will not consider it disrespectful if some of their recent guests declare that they are not entirely convinced of the Devonic character of these quartzites and schists which form the Oural divide. Only general considerations extenuating this inability to accept the Russian Survey's determination as final are here in order. In the first place the time was not sufficient to observe the contacts M–D_1^1 c and D_1^1 c–D_1^1 g, and D_1^1 g–D_1^2. The first two of these are nowhere so explicitly stated in the Livret Guide as to establish the impossibility of faults. The absence of fossils where these beds were seen deprives us of much needed light. Then again the absence of such important orographic elements as the entire Siluric, Cambric, and Archean is very hard to accept, especially after the investigations of Murchison. The question is one of the highest interest and importance, and it is hoped that more light may be shed upon it in the near future.

There is another consideration which it must be confessed aids in preventing an immediate and unquestioning acceptance of the Russian structure, although it cannot be dignified by the title of an argument, and can be mentioned as an analogy only and with every reserve. Taken, however, together with the other considerations, it is not entirely destitute of weight:—

If we might for the moment leave out of consideration the horizon of the limestone D_1^1 c, and its determination as Devonic we find petrographically an analogy too strong to be overlooked between the sequence of the formations from the crystalline eruptives and

massives, and the schistose and calcareous quartzites and sandstones in other countries and in the Ourals. Of course if it be necessary to accept the series D_1^1 c as Devonic underlying the quartzite series D_1^1 g, this important quartzite member which is petrographically and schematically such a striking analogue of the Cambric (Potsdam) or Primal quartzite is lost: but even then the group M is not proven to be Devonic or even paleozoic by any evidence which it was possible to present to the participants in such a long and comprehensive excursion. The writer does not mean in any way to deny that evidence exists which establishes the original paleozoic character of the group M, he only wishes to say that none such was seen by those fellow members of the excursion of whom he inquired. Of course long and patient investigation is required to place a critic of the Russian Survey's proposed structure in a position to exercise his office. If, after all, this scheme is to stand, it will add another feature (and, perhaps, that which caused all the rest) in which the Oural chain stands out alone among the mountain chains of the world.

Here then is the greatest of the cruces brought to light by the labors of the Russian geologists, and laid before their guests at the recent Congress. It is one which far transcends in interest and importance the Volgian, Tartarian and Permo-Carbonic questions.

The difference in importance between the problem of such a structure and that of the permanent taxonomic value of the series P–C, P–T, Pb (Tartarian), J–Cr (Volgian), Q^K (Caspian), or Cr^V (Aptian), is that while in these latter cases the sequence is universally admitted, and the only question is whether the members of these groups should be ascribed to one of the upper or lower series, should be divided between them, or in whole or part should stand alone; the question in the first case is whether three of the great mountain building systems are entirely wanting in the composition of the Ourals.

The peculiarity of the Oural chain which most strikes the observer is that approaching from the western side the divide is reached before half of the Paleozoic series are crossed, or any of the continent backbone-making systems have appeared on the surface. From the end of the first quarter of an ordinary mountain chain crossing, one looks over the remaining three-quarters, (or where they ought to be) into the boundless lake-covered steppes of Siberian Asia. But another surprise is in store for the traveller. Approaching the Ourals

from the west there is nowhere the bold, rugged landscape that one sees in the Caucasus or in Switzerland. It is only by looking back on the steep basset edges of the formations that one realizes the mountainous character of the region. But starting from Ourjum to cross the Eur-Asian line, and descending from that line into Siberia towards Miass the mountainous character is lost altogether. As M. Karpinsky justly says (L. G., V. 2): "On the east slope and at a short distance from the axis the region loses almost at once its mountainous character so completely that, though its geological structure corresponds with a very complex mountain region, the greater part of it presents an area so flat that the relief is less accidented than that of most of the plains of European Russia."

It is like entering the basement of a house built on the steep side of a hill and climbing to the roof to find that a broad plain stretches itself out from that level. This is the first feature to strike the observer. The second is a corollary of the first, namely the infrequency of exposures. The third is the enormous development of lakes. At least one-third of the surface of these steppes is covered by water which is supplied from countless bogs and morasses lying in all positions on the east side of the chain from close up to the axis to a distance further than the eye could see.[4] It has been mentioned that the water courses of the western half in their inception follow the longitudinal valleys parallel with the axis of the chain for considerable distances and with considerable rapidity before breaking through the transverse gorges of about 10 wersts or kilometers more or less in length to the main water arteries on the trans-Volgian steppes. The reverse is the case with the Siberian streams. With a very few exceptions their early course is directly away from the axis of the chain, and the flow is parallel to circles of latitude for a very considerable distance. Over this part they flow sluggishly from and through impassable swamps, showing few or no outcrops on their banks. The outcrops occur on the comparatively elevated country between the water courses.

On the other hand, in their middle course (which the excursionists could not observe) the outcrops of rock in place are reported as commencing to appear in isolated places, becoming more and more frequent, and finally uniting in a continuous outcrop. The river is

[4] The characteristic features of the water courses to the east are taken from the Livret Guide, as the course followed by the excursion did not permit the participants to actually see the second and third divisions here referred to.

shut in a narrow bed with rocky banks that often assume the aspect of a veritable gorge of 40 m. (131 ft.) and more in height.

The country, which appears ordinarily flat, falls away only in the neighborhood of the rivers, where it is broken abruptly into rocky escarpments. The courses of the streams thus display scenery entirely different from the surrounding country. Their lower courses are said to be distinguished by large, flat, marshy valleys bounded

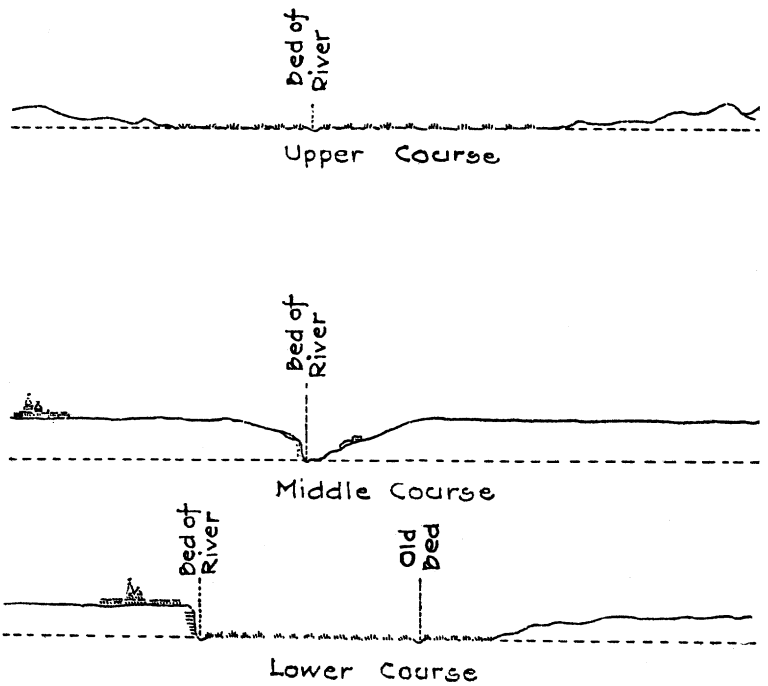


FIG. 2.

by terraces ordinarily rounded and sometimes cut by ravines. The river meandering in this valley and approaching sometimes one and sometimes the other of these terraces, cuts escarpments more or less deep, sometimes vertical, permitting a view of the tertiary rocks and alluvial deposits. Here and there one sees the remains of old river beds called "staritsa."

The following is a free rendering of M. Karpinsky's general description (L. G. V.): In the most important rivers of the east slope of the Oural, such as the Toura, Taguil, Nitza, Irbit, Pychma, Isset, Sinara, Tetch, Miass, Ouwelka, Oui and Togonzak, the lower course is the most extended. Their western limit coincides almost with the western limit of the region occupied by the tertiary deposits. (See the geological map of the eastern slope of the Oural.) The middle course of these rivers is generally the shortest. The rivers of the Asiatic system of the Ourals are also less abundant in water than those of the European system. The vast lake system of western Asia along the Ourals extends from the very mountain region itself down to the axis of the divide (as in the case of Lake Itkoul, etc.).

In proportion to the distance from the Oural chain the character of the lakes changes more and more, and several types united by those of intermediate character can be recognized. Between the ramifications of the Ourals and near the boundary between the mountain and plain of the east slope, lakes which form on their borders islands and rocky promontories in greater or less number are found scattered far apart in a region constituted essentially by crystalline rocks. Their contours, predominant directions, and distribution, depend habitually on the direction of the schistose crystalline rocks forming the region. In this same direction strings of lakes are found ordinarily enclosed in a belt formed by the same rocks (see on map lakes Silatch, Soungoul, Kéréty, Kasli, Irtiach and Bolchaia-Nanoga, Miassowo, Terenkoul, little and great Kissiagath, Yélowoie and Tschébarkoul). All these lakes have considerable depth even near their shores. Most of them have visible outflows, and their water is always fresh. The lakes of the steppe remote from the Ourals have an entirely different character. Their number is very great, as is the space over which they are distributed, which extends far to the east.

These latter lakes are found in a region occupied by horizontally stratified tertiary deposits. Their forms are simple, and in spite of their large dimensions they are ordinarily shallow. Near their margins one often sees terraces of rounded forms, a proof that at one time they occupied larger spaces. Regularity is observable neither in the directions of their greatest elongation nor in their grouping. Almost all of these are without efflux. Many of them contain fresh water, though in others the water is saline, and in a part of them salts have been deposited. The salt is predominantly NaCl with

$MgSO_4$ and $MgCl_2$. Almost all of these show evidences of gradual drying up. It is worthy of notice that the salinity of the lakes is subject to changes of weather and of the seasons.

The eastern limit of the crystalline region characterized by lakes of type I is separated from the western boundary of the region of tertiary deposits with the lakes of the steppe by a belt composed partly of sedimentary and partly of massives and clastics (tuffs). The lakes of this belt are characterized by certain characters of each of the foregoing types, *i. e.*, the simple form, and straight and low beaches of the steppe lakes and the rocky islets, and correspondence of the lines of their greatest extension with the strikes of the enclosing rocks which are peculiar to the mountain lakes.

The marshes deserve notice. Some are the beds of old lakes now covered with vegetation. Sometimes the small lakes are covered with a mantle of swampy interlacing vegetation. Others are situated on the belt which divides the rivers, and frequently on the quite steep slopes of the hills, independently of the marshes in evident connection with the lakes.

Finally there are regions of salt deposits which characterize the east slope of the Oural. The thin sheets of salt which appear from time to time covering even the plants indigenous to saline terraces with a layer of salt, are developed in the saline lake region, but some small deposits are found in the western region and quite high up on the slope. The variation in the distribution of the saline lakes depends not only on the water infiltrated through the soil, but also on the wind scattering the pulverized salt into the lakes for longer or shorter time.

The rocks most frequently encountered on the east slope of the Ourals are (commencing with the oldest) the lower Devonic (Hercynian), represented by limestones, and containing a fauna described by Tschernischew. Among the characteristic fossils are *Eutomis pelagica, Aristozoe herzinica, Spirifer indiferens, Atrypa reticularis, A. granulifera, Rhynchonella princeps, Rh. nympha, Pentamerus galeatus, P. procerulus,* var. *gradualis, P. striatus, P. vogulicus, P. pseudoknighti, Strophomena stephani.* The tuffs accompanying the porphyrites contain also organic remains (Pentamerus, Crinoids, etc.). Radiolaria have been discovered by Tschernischew in the jasper of the Ourals.

The middle Devonic seems to be represented by limestones with corals and stromatopores. *Grünwaldtia latilinguis, Rhynchonella*

procuboides, Orthis striatula, Pentamerus galeatus and the trilobites near the village of Pokrovskoie in the district of Irbit *Phacops fecundus, Anarcestes lateseplatus, Pleurotomaria subcarinata, Tentaculites acuarius.* To the upper Devonic may be classed the limestones of Lake Koltouban, *Monticocerus intumescens, Spirifer disjunctus, Sp. Archiaci,* etc. The Carbonic system is composed of (1) schistose clays and argillaceous schists, sandstones and conglomerates, with intercalations of coal and concretions of Spherosiderite. The organic remains are almost exclusively plants (*Lepidodendron glincanum, Stigmaria ficoides*). At times the rocks are much metamorphosed, and the carbonic schists are transformed into graphites with vestiges of plants. (2) Limestone with *Productus giganteus Pr. striatus,* corals, etc. (3) Limestone of the upper horizons, those of Chartymka, the fauna described by Verneuil. *Gastrioceras marianum, Pronorites cyclolobus* var. *uralensis.* One hundred species of fossils have been found, of which many have not yet been described. (4) Ordinarily the limestone of *Pr. gigant.* are replaced above by a schistose limestone, or by a coarse conglomerate, in which the fragments of limestone of different sizes are held together by a calcareous cement. The conglomerates are replaced by sandstones covered by marls or argillaceous limestones finely stratified with subordinate beds of limestones sometimes coralliferous (*Chætetes radians*) *Syringopora parallela, Spirifer mosquensis.* Above this is a clay with Gypsum.

On the east slope of the Ourals are found islets of mesozoic deposits: clays and sandstones containing lignite. In general the fossils are badly preserved remains of plants. (*Asplenium whitbiense* var. *tenuis, Phyllotheca striata, Prodozamites lanceolatus* etc. and remains of *Estheria minuta* var. *karpinskyana.*)

Finally on the east slope of the northern Ourals occurs the upper Jurassic, containing Ammonites; deposits of lower and upper Cretacic with *Baculites* beds of upper Cretacic with *Belemnitella mucronata, Gryphea vesicularis,* etc.

The tertiary sediments are very remarkable. Commencing at 50 to 100 kilometers from the axis they extend in horizontal beds which grow continually thicker into the interior of Siberia. The predominant rocks of these sediments in the zone nearest to the Oural are sandstones, presenting sometimes very peculiar characteristics, and particularly, a rock composed of an intimate mixture of amorphous clay with an equally amorphous silica. This material covers a very

large area. It appears as a compact rock of light or gray color, sometimes yellowish, of which the typical varieties have the property of disintegrating into minute particles with angular points and curiously curved surfaces. Fossils are extremely rare in these beds. Alongside of the teeth of squali, spiculæ of sponges and of radiolaria, are found the shells of *Lingula*, prints of shells of *Lima nucata*, and the sponge *Botroclonium spasski*. Various considerations have induced the Russian geologists to ascribe these beds to the Eocene.

To the east of these silico-argillaceous beds are widely distributed sandstones slightly coherent, accompanied by sands and clays. In these deposits are found well-preserved remains of fishes: *Lamna elegans, L. cuspidata, L. denticulata, Otodus macrotus, Notidanus serratissimus, Galeocerdo minor, Actobatis, Myliobates* etc. Besides this the remains of mollusks have been found; the species most widely distributed—*Cyprina*—resembles very much *C. perovalis*. In addition occur *Modiola, Psammobia* (?), *Fusus* (*Neptunea*) *gracilis, F. multisulcatus* and *Nautica* sp. The above are classed as Oligocene.

Among the most remarkable deposits of post-tertiary age of the east slope of the Oural besides the glacial deposits developed north of the 61st parallel are the auriferous and platiniferous sands (the latter belonging exclusively to the Ourals). Intimately connected with the serpentines and their primitive rocks, to the disintegration of which the platiniferous groups owe their origin, they are not so largely developed as the auriferous placers.

The auriferous placers of the Oural are stratified masses, which vary from a very thin layer to a thickness of 4 meters and more. Generally they vary between 0·5 meters and 1 m. Their longitudinal extent, which is usually 20 to 40 m., often reaches 200 and even 500 m. They are rarely more extensive, though placers of 4½, 6 and 12 kilom. are known (placer Pechtchanka, District Bogoslovsk). Their width is sometimes very small, 2 to 4 meters; ordinarily it is 20 to 40 m., and has been known 100 m. and more. Sometimes auriferous beds are found on vegetable earth or immediately under the grass, but usually they are covered by barren earth, *i. e.*, an alluvial bed destitute of gold, called "turf," because the first placers found in the Ourals were covered by a real turf. The barren earth varies from 0·5 m. to 4 m., and occasionally reaches 20 m., and even more. The placers usually rest on hard rock, or that little disintegrated, called

"plotik," but rarely on a barren alluvial bed under which is found a second auriferous bed which reposes directly on the "plotik."

The auriferous placers are found in the valleys of rivers and brooks, or in dry ravines, and, of course, follow the axis of their depressions. A gold nugget weighing 36 kilogr. (lbs. 79.2) was taken from the Tzarévo-Alexandrowsky in the Miass district. Often a slender thread in the placer is found to be richest in gold, and probably indicates the strongest current. The gold of the explored placers varies between 0·57 gram to 2·69 grams per tonne. A larger yield is rare and when found is in the small placers, or in small parts of large placers where it sometimes reaches 16 kilos. per tonne. It is usually accompanied by Magnetite, which is obtained in the washings as sand called "Schlich." More rarely this sand is composed of Hematite, Ilmenite and Chromite. Frequently Quartz and often Platinum, Garnet, sometimes Zircon, Disthene and Diamonds are obtained. The richness of the Oural placers does not seem to depend on that of the neighboring rocks. The most important placers are in regions of greenstones, crystalline, talcose and chloritic schists, etc. The regions of granite, gneiss and mica schist are less productive. The placers on limestones are often found to be peculiarly rich. In this case the rock is cut out in the form of natural buckets, in which the gold is deposited. The Oural placers are post-tertiary, or recent deposits, containing objects fashioned by man, and occasionally post-pliocene deposits containing the remains of mammoths, rhinoceros, etc. Almost all are on the east, very few on the west slope, of the Oural divide. Among the crystalline stratified rocks here are gneiss with Biotite, Muscovite, with two micas, amphibolic, uralitic, etc.; micaceous, talcose, chloritic, siliceous amphibolic schists; various phyllites and quartzites. Among the crystalline schists, limestones and dolomites (marbles) are found sometimes with organic remains. Among the massives, granites, various syenites, miaskite (Nepheline syenite with Biotite), quartz porphyries, felsite, orthoporphyries, diorite, gabbro, norite, diabase, various porphyrites, various peridotites, diallages and pyroxenites, serpentine and a mixture of Corundum and Anorthite. Many of these have been subjected to more or less dynamic metamorphism, to which among other things the green and uralitic schists owe their existence. The mutual relations of the various formations here are confused from the dislocation of all the deposits (with *the exception of those of the tertiary, post-tertiary and upper cretaceous,* which latter is rarely

met with) and the cutting of all the sedimentary rocks by the massives. The rocks above mentioned occur sometimes in their natural order, but often without any regularity whatever. The beds generally do not dip with the slope but to the west. In proportion to the distance from the axis of the chain the stratification becomes less deranged and the metamorphism feebler, *nevertheless on the eastern slope up to the appearance of the tertiary deposits in force the* different formations alternate without any order. The conclusion of M. Karpinsky is that the principal abrasion of the region has been due to the invasion of the tertiary sea (paleogene), and a considerable part of these deposits have been formed at the expense of the older rocks then rising above the present level of the country. The difference in the geological structure in the two sides of the Oural is reflected in their mineral wealth. Thus the stratified deposits, such as limonite, cupriferous sand and coal, are found principally on the west side of the chain, while the vein or massive deposits are found on the east: the placers are the only stratified deposits of minerals peculiar to the east side.

After the above, which is the resumé by M. Karpinsky of the structure of the east slope of the Oural,[5] it is, perhaps, the best place to consider the interesting question of the cause of this structure which the travellers over the route of the excursion have verified as accurately stated. Several points have been emphasized above to call attention to the part which they bear to the hypothesis advanced by one of these excursionists.

Prof. Götz of Munich is of the opinion that but two hypotheses are tenable. The first is naturally that the lake basins have been ploughed out by ice or other powerful physical agents (which he concludes cannot be maintained), and the others that they are due to atmospheric agencies—chemical and mechanical.

The writer's first suggestion, which he afterwards found had been advanced independently by Prof. I. C. White, was that the subjacent limestones had been dissolved out by waters percolating the soil and the depressions thus formed had been filled with water.

The following is the hypothesis of Prof. Arthur M. Miller, of the State College of Kentucky, Lexington, Ky.:

"A" (Figure 2) represents the course of a tributary stream of the Irtysch, draining the Asiatic slope of the Ourals.

[5] L. G., V.

"Prof. Karpinsky states that every one of these streams is divisible into three courses—a fresh-water-lake-region upper course, a gorge-region middle course, and a meander-flood-plain-region lower course.

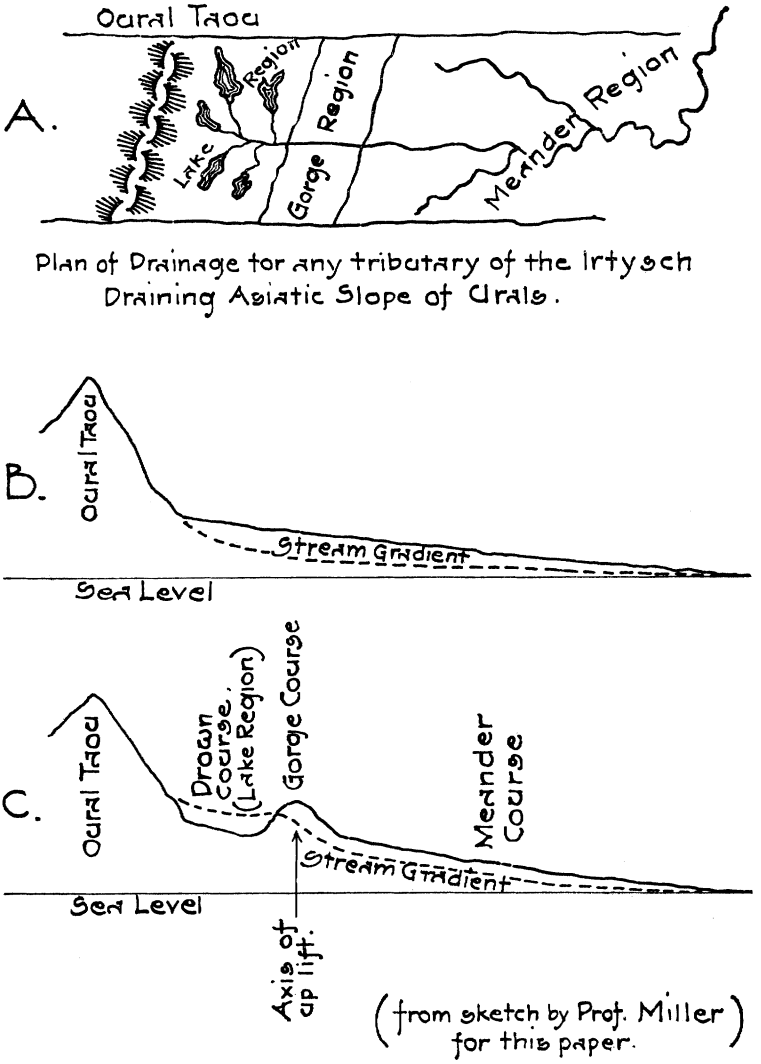


FIG. 3.

It is the peculiarities of the upper and middle courses that here demand explanation."

"The presence of lakes nearly always point to recent disturbances in the drainage."

Recognized causes of lakes are:—

1. Glacial action.
2. Volcanic action—crater hollows and lava dams.
3. Chemical solution—producing inequalities.
4. Epeirogenic movements—phenomena associated with draining of newly established marine plains.
5. Sluggish stream action in deltas and flood plains.
6. Minor warpings of the earth's crust—causing changes of gradient in streams.

Of course we readily rule out causes 1 and 2 here. There is no evidence of recent glacial or volcanic action in this region under discussion.

Cause No. 3 would find some advocates as applicable here; but evidence in favor of lakes being formed in this way is meagre.

Cause No. 4 could have hardly operated here, though it may have had influence in the case of the salt lakes of the Siberian steppe region farther to the eastward.

"No. 5 must also be ruled out; we are not dealing with lower stream course phenomena."

"We seem limited to Cause No. 6. Fig. B represents supposed section of district "A" just prior to the development of the lakes and the gorge. We have here in the dotted line the low stream gradient of a plain lying at base level. Suppose a gentle warping of the earth's crust to produce a fold (not a fault) with an axis parallel with the main chain of the Ourals. This is represented on an exaggerated scale in Fig. "C." Such a fold thrown across the paths of these eastward flowing streams would increase the gradient of that portion of their courses on the eastward half or limb of this low anticline. The erosive power of the streams would be intensified in this portion of their course. They would tend to cut gorges. In the upper course of the streams, that portion between the developing anticline and the Oural-Taou, the gradient would be lowered, perhaps even reversed, for the movement upward on the western limb of the anticline would act in opposition to the current, and form a barrier, which would tend to dam up the waters behind it. In addition to this there would probably be a downward synclinal movement in the region between the anticline and the Oural-Taou. The floor of the syncline would not only be relatively but absolutely lower than it

was before. The combined effect of these two movements would be to drown the upper course of these streams and favor the formation of lakes."

The hypothesis first referred to, for which I find that I am responsible, is built upon the admitted structure of the river beds in their divisions described above, and is in effect that at some time posterior to the deposition of the rocks of the middle course, a profound dislocation occurred along the Ourals involving an upthrow of the entire eastern half along a line of fault parallel to and not far from the axis of the chain, which brought the underlying Archean rocks to the level of the Devonic of the western slope. The entire series of rocks forming the eastern slope as far as the present westernmost occurrence of the rocky gorges of the middle slopes were affected by this movement. The high angle and great precipitation cut channels for the rapid streams directly eastward, and ploughed out the cañons in the Tertiary rocks of the Siberian plains. A period of erosion ensued during which the elevated eastern half of the Oural was greatly reduced in height. Following this was a down-throw of less extent than the original elevation but of sufficient extent to reduce the rapidity of flow of the rivers near their sources and on their upper courses, and to transform these latter more or less into morasses and swamps. In time the sunken river beds of the upper courses werefilled by sediments, while the rocky gorges of the middle courses remained as before the channels of streams no longer possessing sufficient rapidity to have cut them. It seems reasonable to suppose that if there had been such movements, they might have produced all the dissimilarity now observable between the two slopes of the Oural, even if the structure of the two sides had been originally similar. The rivers of the east slope prior to the first movement probably originated in the longitudinal valleys of the harder crystalline and quartzite rocks of the east side. Their first courses very likely were rapid and tumultuous and more or less parallel to the axis of the chain, as is now the case with those of the west side, for considerable distances or until favorable places were found for them to break through in lines perpendicular to the axis of the range, when like those of the western slope they may have excavated their beds, first through the older paleozoic rocks and further east through the Tertiary, and finally have reached the level steppes far to the east. The first effect of the elevation would be naturally to produce direct east

trending channels and to cut them so deeply that they would still remain the water courses after the subsequent depression. The final sinking of the eastern half of the chain, would convert the river channels already cut out of the crystalline rocks into deep lakes lying as it is shown these do, more or less in the same direction and within a belt of moderate width. The currents of the upper courses must have become sluggish and the sources of supply have changed to morasses and swamps. The gentle slope directly to the east would be the natural direction of these streams, instead of as originally before the first elevation of the longitudinal valleys, to the N. and S. Wherever depressions of the level occurred, would be found a lake of greater or less extent and these lakes would increase in number and simplicity of form as the angle of descent became less and the rocks softer. The promontories and deep slopes of the old river-bed lakes which represented the parts of more than usually hard rock where the mountain streams had been deflected, and the deep cañons where the maximum erosion had been accomplished, would be less and less frequently seen, the further one followed the river courses to the east. The production of lakes with and without efflux in the level region would follow as a matter of course as is seen in the courses of the Mississippi, the Volga and other large streams.

The existence of the third or intermediate type of lake of which M. Karpinsky speaks, lying between those close to the Oural axis and those on the steppes would be very natural in a part of the country where both orographic and petrographic characters were changing from those of the rocks containing the lakes of type I, to those containing the lakes of type II. Finally many of the shallower lakes would be transformed into marshes and swamps.

On the other hand the existence of large masses of metamorphosed rocks; of the evidences of distortion and crushing; of rents filled by eruptives and their disintegration products; the occurrence of valuable mineral deposits in that part of the mountain system nearest to the axis; would be naturally explained by the dynamic and thermal effects resulting from the regional downthrow. It appears much at least as plausible that such causes acted as that the former eastern counterparts of the rocks constituting the west slope of the Oural have been eroded and redeposited as the rocks of the retreating Tertiary sea.

On July 31 (August 12), 1897, we left Slatooust for Orjum, where a halt was made, and a few hundred yards beyond which the continental divide forming the Eur-Asian frontier was reached and passed, and the moderate descent on the Siberian side to Miass at the foot of the Ilmen mountains begun. On the road thither, and at the station Syrostan, a cutting exposes phyllites, a porous talcose rock (listvénite) and serpentine. Further on schistose rocks including metamorphosed porphyrites occur. The other secondary elements are Chlorite, Quartz, Calcite and Epidote. After these, alluvium covers the surface to the station of Miass. Almost the entire region between Syrostan and the Ilmen mountains is auriferous, the central part of the auriferous belt containing the site of the town of Miass. The gneiss on which the town of Miass is built traversed within town limits by peridotite, in its western part is replaced by siliceous schist (kieselschiefer) and phyllite. The Miass placer situated only two kilometers from the station is typical of the eastern Oural deposits of this character. The bed above the auriferous gravel is about 2 to 4 m. thick, and consists of turf, sand and clay. The auriferous bed itself consists of argillaceous sand with many pebbles, and of gravel containing fragments of gneiss, quartz and siliceous schist, of 0·7 m. in thickness. The gold varies from 0·6 to 0·8 gram per tonne. This bed lies on gravel, sand and clay, 2 m. thick. Borings show talcose and argillaceous schists and serpentine below it. A little gold is found above these rocks, but not in paying quantity. The placer which lies in the ground immediately adjacent to the Miass river is about 1,380 m. long by 320 broad. The terrace is the ancient bed of the river. The gold is sought in the lowest points of the ancient and present valleys. The peat or turf which lies upon this gravel is that which extends over so large a part of the Siberian steppes and in which at other places the remains of the mammoth and rhinoceros have been found. The river is about 500 meters east of the present workings. This placer was stated to be but 60 m. above sea level, and the mouth of the Miass but 40 m. (?).

The gravel is screened in a primitive circular rotating screen, of which the axis is inclined, and is then passed over a table having two amalgamated plates at the top and two at the bottom. The shoot is about 5 feet wide and 35 feet long, with a fall of about 20°. The coarse slimes are carried to the top of a scaffolding, while the fine slimes are left.

The Ilmen mountains which lie close to the town of Miass are celebrated as the depository of many, both intrinsically and scientifically valuable minerals, some of which are peculiar to the range. Thus, Miaskite (nephelinic or elœolitic syenite with Biotite), named by Gustav Rose, is not peculiar to these mountains only, which bear the name of Ilmen, but also to their prolongations and the mountains Baiksky, Sobatchia, Potaniña and Wichniowaia. In this continuation another characteristic rock is found composed of Anorthite and Corundum. In the gneiss of the Ilmens and their northerly prolongations veins of a rock composed essentially of corundum and orthose are found. M. Karpinsky considers this an analogue of the syenites, the corundum taking the place of the biotite.

The Ilmens are thus more uniform and characteristic throughout the 150 kilom. of their length than the main chain of the Oural itself. "Miascite" (or Miasskite, or better Miassite or Biotite-nepheline Syenite) is found in many places in the Ilmens, of which the chief is near Lake Ilmen. There and in most of the other localities are developed the granular and gneissic varieties of Miassite, cut by veins of very coarse-grained Miassite. A foot note in L. G. V., 22, gives the following as yet unpublished analysis of Miassite by M. Bourdakow:

	I	II	III
SiO_2	52.03	56.26	54.17
TiO_2	0.99	0.47	0.98
Al_2O_3	22.34	23.59	23.25
Fe_2O_3	1.13	0.85	0.69
FeO	1.63	2.61	2.95
MnO	0.41	0.09	0.16
CaO	2.09	0.54	2.02
MgO	0.67	0.27	0.48
Na_2O	8.44	7.77	6.33
K_2O	5.16	5.72	6.19
CO_2	1.32	1.37	1.14
H_2O	1.79	0.37	0.17
	98.00	99.91	98.53

I. Granular Miassite near Lake Ilmen.

III. Schistose Miassite from Mt. Sobatchia.

II. Schistose Miassite from Mt. Wichniowaia.

There are over 150 mineral localities exploited in the Ilmen mountains in the neighborhood of Lake Ilmen. The minerals (of which a list of 83 is given in L. G. V. by Karpinsky, and 35 are

specifically described by Arzruni in L. G. IV) lie either in miassite, syenite or gneiss. The veins most extensive and remarkable for the minerals they contain are in a peculiar green granite traversing the gneiss. The granite typical of the veins consists of amazon stone (microcline), albite, gray colorless or almost black quartz and biotite. The miassite is often very coarsely granular, the individual crystals attaining frequently 10 centimeters and more, and a specimen of biotite weighing 62·67 kilog. having been found. Some fine graphic granite is formed of quartz and amazonite.

The rock contains cavities filled with argillaceous matter called "salo" (grease) in which are found attached to the walls finely developed crystals of Topaz and among other minerals, Beryl (Aqua marine), Phenacite, Tourmaline, Columbite, Samarskite, Monacite, Monazitoid, Helvine, Garnet, Malaconite, Cryolite, Chiolite, etc.

The veins of micaceous syenite, consisting of Orthose, Plagioclase, Biotite and sometimes Muscovite, which cut the gneiss, contain very various minerals: Zircon, Pyrochlore, Æschynite, Monacite, and sometimes Apatite, Sphene, Magnetite and Ilmenite.

On August 1 (13) the portions of the Ilmen mountains near the station were examined by the excursionists. The distance to the first opening was about 4 wersts, exhibiting miassite containing Zircon, Elæolite and Nepheline.

Besides typical miassite we obtained Elæolite with white masses of Nepheline, Biotite and Ilmenite. The Ilmens themselves are the most gently sloping of hills and of very moderate height. Further on were found openings where Sodalite and Amazon-stone were procured. Among the more important minerals, of which more detailed description will be found in L. C. IV by Arzruni, are Æschynite, Amphibole, Apatite, Beryl, Cancrinite, Chiolite, Columbite, Desmine, Elæolite, Epidote, the Feldspar group, Microcline, Fluorite, Garnet, Graphite, Helvine, Ilmenite, Corundum, Cryolite, Magnetite, Martite, Mobybdenite, Monacite, Orthite, Phenacite, Pyrochlore, Quartz, Rutile, Samarskite, Scapolite, Sodalite, Titanite, Topaz (which was the first mineral found here in the XVIII Century by the Cossack Protow), Tschewkenite, Tourmaline, Uralite and Zircon.

After an examination of these localities the route was continued toward Tchéliabinsk. At the station Bichkil a party of ten excursionists set out in droschkes sixty wersts to visit the gold deposits of Katch-Kar (or Kotch-Kar). This region is situated 80 kilometers southwest of Miass. The 360 to 400 mining localities that the dis-

trict contains are found in the upper course of the rivers Kotchkara, Tschornaia, Osseika, Kamenka and Sanarka. The exploitation of gold began in 1844, when the placers in the southern part of the region Kamenka and Sanarka were discovered. Later these placers became famous on account of the precious minerals, Cyanite, Beryl, Rose Topaz, Amethyst, Euclase, Ruby, Corundum etc., which occur with the gold. The first gold in primitive rock in place was discovered in 1863.[6]

The auriferous region lies in the middle of a large granite zone running north and south. The gneisso-granites strike approximately east and west, but have been broken through in a direction perpendicular to this, as is shown in numerous more or less parallel cracks and faults. The faults have in their turn caused the enclosure as veins of masses of granite transformed by dynamo-metamorphic action to a dark greenish gray rock generally schistose, and composed of very finely crushed masses of Orthose, Plagioclase, Quartz and Mica, with secondary elements, Biotite, Amphibole (in certain veins), Chlorite, Talc, Calcite, Pyrite, etc. The country rocks are a granite called bérézite with Feldspar partially or entirely transformed to Quartz and Muscovite. The thickness of the exploited veins varies between 0·05 m. and 2 m. The veins consist of gray or green opaque Quartz, in which are inclusions of little veins of Chalcedony in very variable quantities (here and there of Calcite and Chlorite), but filling the whole crack. The Chalcedony is represented principally by Mispickel, Pyrite mixed with Chalcopyrite, Stibine and Galena.

Over the greater part of the mining area the primitive rock is disintegrated on the surface to a depth of 20 to 50 meters. The granite is transformed to a pinkish-white clay, unctuous to the touch. The Quartz becomes spongy, and contains the products of the oxidation of the Chalcedonies, Ochers, sometimes oxides of manganese and copper, here and there Pharmacosiderite and Arseniosiderite, also haloid silver minerals with the appearance of Embolite Ag (Cl Br). The gold content is 5 to 13 grams per tonne. The veins are richer at the top, although the gold is more equally distributed in the lower parts. The gold augments proportionally to the amount of mispickel, and contains about 30 p. c. Ag. The different localities of ore resemble each other closely. Up to the present time that

[6] The information as to this region is taken from Wyssotsky's description in L. G. VI.

part of the belt of sufficiently disintegrated rock which allows the extraction of ore by the simplest processes (crushing and amalgamation) has alone been exploited. To separate the chalcedonies the "stossherd" and Frue vanner are used. The most important operations are those of the Mitrofanovsky shaft (40 m.), Woskressensky (80 m.), the shafts Gavriilo-Arkhanguelsky (70 m.), Loukochinsky (73½ m.), Woskressensky (56 m.), Pavlovsky (50 m.), Alexandrovsky (63 m.), etc.

In latter years the yield of gold from the primitive rocks, where it occurs as an ore, has been 1300 to 1425 kilogr. per year for the district of Kotchkar, while the placers have given but 300–350 kgr. The total production of gold from 1844 to 1897 in this region is about 47,067 kgr. (103,547.4 lbs.=51.77 tons) of which 25,160 kgr. came from the placers, and 21,900 from the veins (since 1868). To this some 450 kgr. of silver must be added.

Amphibolic and biotitic gneisses crop out over the entire space which stretches to the Lake Tschébarkoul, and beyond veins of the amazonite granite disappear imperceptibly, but the ordinary ouralian granite with Biotite grows more frequent and extensive until it becomes predominant. The gneiss squeezed between masses of granite contains frequent injections of it and innumerable dykes and veins. Beyond Tschébarkoul the outcrops become more rare. At 4½ kilom. from the station siliceous schists appear, interrupted by a serpentine; further on, chloritic, talcose and argillitic schists succeed. These schists are replaced by green-stones, augitic and ouralitic porphyrites and aphanites, transformed here and there by dynamo-metamorphic action into uralitic schists. Here and there along the line of the railway gold is exploited in placers and veins.

On August 2 (14) the party moved along the line of the trans-Siberian railway to Tchéliabinsk, the easternmost point which was reached during our sojourn in Russia, viz., over 30° east longitude from St. Petersburg, or about 61° E. of Greenwich. This very important railway center is a new town built on a number of gold veins which have been exploited in latter years. The mines are mostly from 16 to 20 kilom. southwest of the town, and have a general similarity to those of Kotchkar. One of the best organized mines is St. Michael Arkhanguel, belonging to M. Wonliarliarsky & Co.

Along the line of the railway towards Kytchtym the granite is followed for 8 kilom., and near the crossing of the Miass is cut by ramified veins of quartziferous diorite. The granite underlies red

and yellow post-tertiary clays covered by tschernozem. From the 7th to the 52d werst from Tchéliabinsk the clays cover the oldest rocks almost everywhere. It is only in rare instances that one observes the islets of tertiary conglomerates and sandstones, which have escaped erosion, appearing above the surface (12 to 43 wersts) and siliceous clay with Glauconite (44 wersts), a Kaolin produced by the alteration of a subjacent granite, a diorite (?) (32 wersts), a dioritic porphyrite (Lake Kissiagutch) and a Labradorite porphyry (46 wersts). From the 50th werst such outcrops become more frequent. First come aphanitic and other massive altered and clastic rocks. At the 64th werst an uralitic porphyrite occurs, becoming an uralitic schist; then serpentine and chloritic schist, and finally gneiss and granite alternating with chloritic and uralitic schists, which predominate further on, and upon which are built the Kytchtym works. The gneisses are often biotitic, often amphibolic, and often garnetiferous. The strike of all the crystalline rocks is nearly that of the meridian. (L. G., V, p. 33.)

August 3 (15) the party of excursionists left the station of Kytchtym in droschkes and drove around lakes Kytchtym and Sougomak to the base of the Sougomak mountain. Between Kytchtym and Sougomak mountain only biotitic and amphhibolic gneiss were observed, cut by peridotites more or less serpentinized on the north of the lake. At the same place appear in irregular prominences masses of granitic and syenitic character. The mountain is partly schistose, and contains limestone with a grotto among the gneiss, but in the main it is composed of massive, extremely tough serpentine with antigorite. From the summit of the mountain a magnificent view is obtained of the Siberian plain and of the mountainous part of the Ourals.

The ascent was along the border of Kytchtym lake and through the town of that name around lake Sougomak and up to the arrête over a grassy slope of easy grade. Hence, the ascent was completed by a circuitous path over a species of col to the shoulder beyond, where a path led up to the summit. On the top was a fine compact rock determined to be serpentine. The view from here of the Siberian lakes and steppes was very extensive. To the west the Ilmen mountains were in sight and also Mt. Yourma, which Humboldt erroneously supposed to be the nucleus of three independent mountain chains.

From Kychtym to Ekathérinebourg the road passes over bands of gneiss cut several times by granite (traversed by veins of syenite). There is a region of chloritic talcose, etc., schists among which is found for instance at the 91stwerst uralitic porphyry transformed to schist. At the 99th werst these schists change the west dip to south for half a werst. Beyond the station Maouk, where the schists have been studied by Morozéwicz, serpentines occur and predominate to the 115th werst.

The chloritic schist contains large crystals of Magnetite, the talcose schist nests of radiating Actinolite of emerald green, and the serpentines a number of veins of Asbestus. The whole is covered by a bed of turf three meters thick. The serpentine contains marble at the 126th werst. Among numerous hills of serpentine one may observe numerous nuclei of gabbro and gabbro-diorite, and other rocks giving origin to serpentine. The summit of the divide between the waters of the Tschoussowaia and those of the system of the river Isset consists of chloritic schist. Marble accompanied sometimes by listvénite has been exploited for years in the vicinity of the village Mramorskoe. Succeeding this for six wersts or more come gneiss and granite, followed by more chloritic and talcose schists, etc., accompanied by serpentines, diallage, pyroxenite, uralitic porphyrite and occasionally by granite and porphyry.

Ekathérinebourg.—Chloritic schists occur within the limits of the city, as well as listvénite, serpentine, diorite or gabbro-diorite, uralitic porphyry, usually changed into green so-called uralitic schist. Here and there these schists contain beds of gneiss.

Besides these (See L. G., VII) in the neighborhood occur limestones and granite.[7]

While a part of the excursionists were examining the so-called stone tents and the archeological remains of Werkh-Issetsky, others visited the mineral localities of Eugénie-Maximilianovna to the

[7] Ekathérinebourg is the seat of a very active and learned society of amateurs of natural history, which has made valuable natural history and archeological collections. A fire destroyed many of the most valuable objects of the former collection, but this has not prevented the growth of the society. Valuable remains of a former tribe have been found on the island in lake Werkh-Issetsk and in the vicinity of the hamlet of Palkino. M. George-Onésime Clerc is the very efficient secretary of this society, a savant amateur, who has for twenty-five years been the chief active spirit within it. He has recently made the discoveries of human relics previously referred to, and desires to be able to compare some of the objects with those of the North American Indian.

northwest of that village, to the right of the river Isseta, and almost on the summit of the Oural divide. Besides minerals about which the data are not yet complete, such as Disthene, Beryl of lilac color, red Corundum, etc., there are met with here Aqua marine, Vesuvianite, Garnet, Essonite and Almandine, Epidote in great abundance, Pouschkinite, Axinite, Yttrotantalite, Titanite, Chinochlore, Amazon stone (Microcline) in great crystals, Amphibole, Rock Crystal Pyrite transformed to Limonite, etc. These occurrences are in a development of gneisso-granites. The predominant rock is a feldspathic rock, poor in mica and almost destitute of Amphibole. This feldspathic rock is accompanied by a rock very rich in Amphibole, sometimes closely associated with amphibolite (Mt. Medwejka, Romanorka), sometimes with amphibolic gneiss (Medwejka, Poup), sometimes with a diorite (Séwernaia, Yélowaia), which occupy lower horizons than the feldspathic rock, although they constitute independent and not very great elevations.

The above minerals are the product of metamorphism. They are found usually at a slight depth in contact with feldspathic and amphibolic rocks, and are almost always accompanied by Epidote. In the mountain Poup the minerals accompany the crystals of dolomite, and are found in places where the dolomite comes in contact with amphibolic gneiss, the surface of the hill being formed of granite. The deposits of the greatest interest are:

Mount Medwejka—Yellow Essonite, rose colored and brown Pistacite.

Mount Yélowaia (Great mine Yevguénie-Maximilianovskaja)—Axinite, Pouschkinite and Titanite.

Mount Poup (Mine Iwano-Rédivotsevskaja)—Essonite, Epidote, Clinochlore.

Mount Séwernaia-Yéréméievskaia)—Aqua Marine, Vesuvianite, Sphene, Garnet, Epidote, Yttrotantalite, Amazon stone etc. [See L. G., VIII.]

The imperial lapidary establishment in Ekathérinebourg, and the depot where minerals, cut and uncut, are exposed for sale, both under the authority of the government and under private auspices, is of great interest, but the cutting was not being carried on at the time the excursion reached the city. The cups and vases of rock crystal, malachite, jasper, etc., were of great beauty, and showed the skill which has been attained by the Russian lapidaries.

The minerals offered for sale comprise all those which are known in the entire Oural region as well as those from this particular district, and have no further claim to enumeration here, since they will be mentioned in connection with the visit to the localities where they occur. This and the other great lapidary institution of Russia at Peterhof employ some of the most skilful artisans in the world.

Leaving Ekathérinebourg on August 6 (18), the railroad passes successively over the narrow belt of diabases, etc., bordering the city on the west, and runs northwest nearly parallel to the upper shore of the lake Werkh-Issetsk through narrow tongues of diallage and limestones, and of crystalline schists called M, into the broad belt of granites and syenites containing lakes Isset, Tawatoui, and others. Skirting the southwest and west shores of these at some distance at about the middle of the last named the road swerves to a direction east of north, and follows a thin band of the crystalline schists, M, to its extremity, then passing along the contact of limestones and diabases, and subsequently through first one and then the other of these rocks across a very complicated area. A long course is made through gabbros, etc.; to the station Anatolskaja, near which is the boundary of the mining district of Nijni-Taguil. Between Anatolskaja and the mining center Nijni-Taguil the road lies in granites and syenites, and finally in diabases, porphyrites and tuffs to Taguil and Nijni-Taguil, which are situated at the contact of these rocks with the lower Devonic limestones and marbles.

Nijni-Taguil the most considerable mining locality of the Ourals, is the property of the heirs of P. Démidow, Prince of San Donato. The founder of the works was Nikita Démidow, who enjoyed great favor with Peter the Great, and established a number of iron works in the Ourals. The river Taguil is dammed at this mining center, and makes a long, narrow lake 12 wersts long, at the northern extremities of which are the hills (or mountains) named Lyssaia-gora (Bald mountain) and Wyssokaia (High mountain). This latter, situated at the west of the village, contains the rich deposits of magnetite which furnish the works of Nijni-Taguil, Niéwiansky, Alapaievsky, Werkh-Issetsky, Soukhsounaky and Révdinsky. At Wyssokaia the predominating rocks are porphyries without quartz, and very varied in respect of their constituent elements. The passage from typical porphyritic texture with well developed crystals of Orthoclase and sometimes of Plagioclase and Augite into augitic syenites or

holocrystalline uralite on the one hand, or into compact orthose on the other is here observed. The intimate correlation of the combined elements of different structure and color appears in the ribbon or spotted structure of the rock, offering a good example of the composition of the "Schlieren."[8] The interpretation of the structure by M. Tschernischew is that the metalliferous masses and the accompanying rocks were formed simultaneously, and that the beds of magnetite have separated themselves from the magma of orthose rocks. The magnetite and accompanying rocks of Wyssokaja dip generally southeast and east, but the structure is complicated by throws and faults to be seen on the west end of the mountain.

Brecciform rocks form the base of the series of metalliferous beds of Wyssokaja. Here can also be seen the disintegrating action of the orthose rocks, which results in the formation of thick beds of white and pink clays, enveloping blocks of magnetite. The iron of Wyssokaja is distinguished for its purity and excellent metallurgical qualities. The magnetite is very often observed passing into martite, a mineral very abundant near Taguil.

Among the minerals of Wyssokaja are Asbolan and Rabdionite, forming in places very thin deposits on the walls of fissures in the Magnetite and Martite. Immediately to the south of these mines occur the outcrops of a white siliceous limestone, which forms the western boundary of the rocks which contain the Médnoroudiansk deposits.

The Médnoroudiansk copper mines are situated to the south of Wyssokaja-Gora, between two narrow bands of limestones enclosing clays, and disintegrated porphyries and tuffs. Along the line of the deposit is found a band of argillaceous limonites and clays.

The southern part of the mine is separated from the northern by a thick vein of lamprophyre oblique to the general direction of the deposit. These iron minerals appear to fill a crack produced by a fault irregularly bounded on the east and west. The clays of yellow ocher are rich in copper oxides, and great masses of Malachite taken

[8] These passages of massive to schistoid and gneissic structure, the insensible transition of gabbros and gabbro-diorites by a series of intermediate phases to diallage and amphibole-diallage rocks composed of only bisilicates, appearing not only on the same outcrops, but even in the same fragment of rock, carry conviction to the mind that these complicated combinations of felspathic with non-felspathic masses which Reyer proposed to call "Schlieren," exist. L. C., IX, 3.

out here have given great celebrity to the mines of Médnoroudiansk. The celebrated block of Malachite weighing 20,000 pouds (lbs. 720,000, or 360 short tons) was found at a depth of 35 or 40 sagenes (245 to 280 ft.) from the surface. In the neighborhood of the limestones the metalliferous rocks become richer in copper salts as the limestones are constantly being dissolved by infiltrating waters. Fossils from these limestones are observed in great number (*Pentamerus vogulicus, Atrypa reticularis, Murchisonia Demidoffi, Pleurotomaria ventricosa, Euomphalus subalatus*). M. Tschernischew concludes that a chemical action takes place at the contact of the limestones and the ore bearing rocks. On the one hand the limestones are dissolved, and from the argillaceous envelope results the insoluble residue. On the other hand the deposits of copper are brought about by the precipitation of this metal, which is carried to the limestone by waters holding it in solution.

The manganese mines of Taguil.—About a werst to the northeast of Lébiajaia is found the manganese mine which is exploited by two trenches. The south wall of the south cut exhibiting bright gray and white limestones dipping southwest 60°, and containing *Atrypa kuchvensis, Spirifer kuchvensis, Sp. pseudo-kuchv., Entomis pelagica*, stems of crinoids and corals. Beneath this is a white dolomite, resting on a marble-like limestone, which is in immediate contact with yellow, pink and violet schists, cropping out in the north wall of the mine. North of the schists appear the same limestones seen in the hanging wall, honey-combed with stems of crinoids and corals. Presumably this represents a tightly folded and inclined synclinal of limestone enclosing the schists. The manganese ore is collected in nests and pockets, and seems to indicate a relation between its occurrence and the lower Devonic limestone.

Ascent of Mount Siniaia.—Leaving Taguil and proceeding north through Laia and to Barantcha the road runs on porphyrites and tuffs. From the crossing of the Taguil to the latter place the road crosses gabbros and diallage rocks. The best exposures of the rocks composing Siniaia are seen in the quarries, which show a diallage alternating with gabbros. Here may be seen excellent instances of Schlieren. The structure is not to be explained by gabbros cutting the diallage rock, for, on breaking it in various directions, even under the microscope, it is impossible to define the limits of the two rocks.

The summit of the Siniaia mountain known as "Koudriawy-Kamen" is almost entirely formed of coarse grained diallage rock containing a considerable quantity of olivine. From the summit of Siniaia or Koudriawy-Kamen (crumpled stone) a splendid view is obtained of the summits of the ranges. To the north appears Mt. Katchkanar, and Mt. Blagodat, to the southeast is the village of Laia and the works of Taguil, to the west is the Oural chain, here running nearly north and south.

Kouchwa and Mount Blagodat.—After a short run of nine wersts north and northeast through gabbros, gneiss, and diabase, we reach the station Kouchwa, on the last named formation, where the crown owns works. The station is at the junction of the great and little Kouchwa. The western part of the village extends over the large low plain of these streams. Two wersts from the town is situated Mount Blagodat. The constituent rock of this mountain, like that of Wyssokaia, is an orthophyre without quartz, but with crystals of Orthose and sometimes Plagioclase or Augite. All transitions from coarse grained uralitic and augitic syenites to perfectly compact orthose rocks *resembling in external aspect the Swedish "Hällaflinta"* as observed by G. Rose. The rocks also approach the structure of "Schlieren." The microstructure, the predominance of Feldspar in the matrix and among the porphyritic elements, and finally the notable content of sodium bring the greater part of the rocks of Blagodat near to the group of quartzless augitic porphyries called, after M. Gümbel, ceratophyres. In Blagodat as in Wyssokaia the orthophyres on the side of diminished mineral masses are enriched by secondary Epidote, by Garnet, Analcime, Calcite, Chlorite and Mica, and pass into epidote-garnetiferous and calcito-garnetiferous rocks. The appearance of these rocks is connected with the disappearance of the masses of Magnetite, as has been proven by the mining operations conducted at Blagodat. The magnetic ores of Blagodat appear as red and as blue. The blue minerals abound in pellets of green chlorite disseminated through the mass. Near the surface the Chlorite is destroyed and the mineral becomes porous and easily fusible. Of course as depth is increased the red mineral is more and more replaced by the blue. The deposits occur without definite boundaries, over the entire east side of Blagodat to the summit wherever there is orthophyre, but sometimes in the shape of tolerably regular veins, and sometimes in nests and nodules. The veins gradually increase in feldspar and pass insensibly into pure Orthose without Magnetite.

On the east side the rocks are separated into strata and dip to the east and southeast. Near the summit the rock is in the form of an anticlinal and the direction of its axis about corresponds with the trend of the mountain.

The deposit is faulted in lines nearly perpendicular and approximating north-northwest and east. As a result of the first faulting, part of the wall of the deposit is thrown to the west flank of the mountain, and owing to the second, the main deposit is cut off to the south on the eastern slope. The folds and faults corresponding with the first of these are anterior to those corresponding to the second or transverse, which accounts for the folding back of the rocks of Epidote and Garnets and their appearance on the west flank to the foot of the eastern slope in many places as a result of the first movement. (See L. G., IX, Pl. F.).

The mineral deposits have experienced the same fractures as the rocks containing them, as is evident from the strips of Magnetite included in the breccias which fill the cracks, and the slickensides of magnetite. The narrow bands of limestone compressed within the porphyritic rocks to the east and south of Blagodat contain a fairly rich fauna often well preserved. The limestones of the lower Devonic (hercynian) along the rivers Kazanka and Izwestka for a distance of 4 wersts southeast of Blagodat abound in fossils, among which M. Tschernischew has described *Calymene, Entomis pelagica, Pleurotomaria kuschwensis, Merista passer, Spirifer pentameriformis, Sp. kuschw., Sp. pseudo-kuschw., Atrypa kuschw., Pentamerus parvulus, Pent. integer, Orthis pseudo-tenuissima.*

The occurrences of these ores of Wyssokaia and Blagodat, and the relation they seem to bear to the orthophyres on the one hand and to the eruptive diabases and porphyrites on the other, will naturally suggest to the mind of the student of Pennsylvania geology the Cornwall and Dillsburg deposits. The quotation by M. Tschernischew of G. Rose's comparison of one of the transition forms of these rocks to the Swedish Hällaflinta only increases the the analogy to the series in Pennsylvania and other parts of the United States, as well as in Wales, to which the late Dr. T. Sterry Hunt so often referred. There are many other analogies, as in the presence of copper and manganese in the Wyssokaja, and the irregular pocket and mass occurrence of the ore in Blagodat. The resemblances in the two countries in these respects is very striking, and is not marred by the Devonic limestones at various

points south and east of Blagodat. It would seem that the complete history of these very interesting mineral deposits remains to be told, and that there is some reason to believe that it will be found to be similar in Pennsylvania, Cærnarvonshire, and the district of Goro-Blagodat.

Recrossing the Eur-Asian frontier.—Leaving Kouchwa the railway continues for a short time in a northerly direction, when it turns northwest before reaching the river Toura. Up to this point it is laid almost exclusively on porphyries accompanied by tuffs and breccias.

The porphyrite breccias consist of a paste of plagioclase and augite, showing plain fluid structure in which occur Labradorite and Augite (partly Uralite). Fragments of different sizes of dark gray ribbon schist, of porphyrite and of quartz, are held in the paste. Occasionally a large fragment of schist a meter in length enclosed in the porphyrite indicates the vicinity of a continuous mass of schists. Up to the present only one outcrop is known, viz.: to the left of the Toura, between the great and little Garevka. About two wersts from the Eur-Asian crossing a region of much metamorphosed gabbros is entered. These gabbros are remarked also west of the station. Then (197 wersts from Ekathérinebourg) commences a region of indubitably metamorphic Chlorite and micaceous schists which constitute the central part of the crest of the Ourals. Beyond the boundary station the railway crosses the Toura for the last time and approaches the head waters of the rivers descending the European slope and mingling their waters with the Kama. [L. G., IX.].

The boundary station between Asia and Europe on the further journey is 426.1 m. (1,397.6 ft.) above sea level, and near the head waters of the Liéwaia Toura, and of the Tiskoss, which latter is an affluent of the Koiwa, and at a distance of 255 wersts from Perm. Following the Koiwa at the ridge near the 237th werst from Perm it attains an absolute height of 285.7 m. (937 ft.).

Following the right bank and turning obliquely to the northwest it ascends a sharp incline of a ridge parallel to that of the main chain, and reaches the maximum elevation of 469.7 m. (1,540.6 ft.). The first cut in the line reveals argillaceous and chloritic schists striking nearly north and dipping sharply to the east. Gray and partly friable quartzites intercalated with disintegrated chloritic schist, yellowish and reddish talcose clays, and light gray quartzites

dipping east 75°, bring us to the 242d werst, where black dolomites of fine grain intercalated with thin veins of calcite dip along with the quartzites. Further on black argillaceous schists and chlorite and argilo-chloritic schists appear. At the 230th werst the gabbros of Douplianoi-kamen, a southern continuation of Teplogorskaja-sopka, are met. From the 215th werst, at the maximum elevation of 469.7 m., the road pursues the crest of the water divide between the affluents of the Wejai and the affluents of the Koiwa, and descends rapidly for 43 wersts to the station Pachya. In the cuts between the 189th and 185th wersts black argillaceous schists occur. Beyond the station Biélaia, in a cut on the 184th werst, a light gray arkose coarse-grained sandstone appears, and further on argillaceous schists alternating with finely stratified sandstone. At the 177th werst light gray, compact and dark gray crystalline limestones of middle Devonic appear with *Cyathophyllum*. From this point to the station Pachya the upper Devonic limestones appear with *Cyrthia murchisonia, Atrypa reticularis, Orthis striatula*, etc. Beyond Pachya the road enters the Carbonic deposits, which it follows to Vsiéswiatskaïa. A cut at the 166th werst shows compact gray fine grained limestones $C\,{}^{2}_{1}\,b$ with *Spirifer mosquensis, Productus cora, Pr. semireticulatus, Pr. Humboldtii, Chonetes variolaris, Fusulinella sphœroidea*, etc. From here to Vsiéswiatskaïa only a few outcrops are seen of white quartzose, fine grained sandstone and clays. The occurrence of Carbonic measures continues. At the 122d werst $C\,{}^{2}_{1}\,b$ again is seen with *Spirifer mosquensis, Pr. cora, Pr. semiret.* Near to the junction of the Arkhipovka and the Tschoussowaia C_2 crops out with *Fusulina verneuili, Pr. cora, Spirifer stri., Streptorhynchus eximiœformis*, etc.

The limestones of the upper Carbonic dipping northeast in the cut of the 121st werst hold a thin bed of calcareous sandstones of greenish gray, with remains of calamites, species of *Productus*, etc., interstratified with a gray conglomerate and an arenaceous schistose clay. The presence of this permo-carbonic sandstone between the upper carbonic limestones dipping to the northeast is explained by a reversed fold to the southwest.

To the north of the station Tchoussowaia the outcrops of the white Gypsum of the permo-carbonic series are seen on a little hill. From the station Tchoussowaia to Perm, a distance of 119 wersts, only Permo-Carbonic, Permian and post-pliocene exposures are found in the infrequent and shallow cuts. Between the stations Liévchino and Motowilikha the road follows the right bank of

the Kama. At the 11th werst a gray, friable, calcareous sandstone P_1^b appears. Between the village Malaia-Yézowaia and Motowilikha is an outcrop of gray friable, partly calciferous sandstone P_1^a horizontally bedded and alternating with marly clays of reddish brown and gray marls. Near Motowilikha the hill is cut by the deep valley of the rivers Motowilikha and Iwa. On the right side of this valley in a hill known as Wychka the greenish or reddish gray calciferous sandstones P_1^b crop out, alternating with clay marls of deep red and thin seams of light gray marl, all covered by sandy clay of yellowish brown, and pebbles. From here to Perm the outcrop is almost continuous of more or less friable calciferous sandstones of greenish or reddish gray color alternating with deep red or gray clay marls, and covered by post-pliocene deposits, more or less yellowish brown sandy clay, yellow or gray argillaceous sand and pebbles. The dip near Perm and Motowilikha is very gentle, but visible S–3°. [L. G., X.]

Perm.—The city is built on the left bank of the great river Kama, which resembles in many superficial features the upper Missouri. The first view of this river at Perm, (which is 650 kilometers over its bed from its source, and about 700 kilometers from its junction with the Volga), is likely to cause astonishment at its breadth and importance; and indeed at the delta near Bogovodskoïe where it joins the mighty Volga, the Kama appeared in August to be the larger stream of the two. The city of Perm is built on quite high hills which are cut deeply by the Tchoussowaïa and by ravines, one of which latter is a short distance north of the town. The Kama is perhaps three-quarters of a mile broad at the landing place of Perm and its banks are reddish on the steep face next to the water. The shores are well covered with sod and the hills back of the flats on the right bank are well wooded and from 100 to 250 feet high, showing in places clearings and cultivated farms.

On the hills of Kama's left bank as well as on those laid bare by the ravines just alluded to, the beds of the upper part of the lower Permian stage, are well exhibited, (P_1^b). They are gray or brownish gray sandstones interstratified with more or less marly red and brownish red clays.

In the river section and also in the ravine just alluded to, these beds are partially covered by a more or less arenaceous clay, intercalated with sand passing in places into gravel. These last deposits belong to the post-pliocene era. The typical Permian of Perm

contains large deposits of copper minerals (principally cupriferous sandstones) which have been exploited until very recently and the ore smelted at the works of Motowilikha. The lower horizon P_1^a of lower Permian can be seen in the mountain named Tschourbina which is on the right bank of the Kama opposite the mouth of the Tschoussowaïa. This horizon of gray calcareous slaty marls interstratified with gypsum and reddish brown sandstones carries the bed P_1^b composed of greenish gray sandstone, interstratified with reddish brown clay. The right bank of the Kama opposite the city of Perm is low and barren, and formed of post pliocene deposits such as gray and brownish gray argillaceous sands with beds of pebbles and recent deposits. A short distance down the stream from Perm these sands lie on the Permian bed P_1^b which contains somewhat cupriferous sandstone.

Throughout the entire distance from Perm to the confluence of the Kama with the Volga, the banks of the former river exhibit exclusively Permian measures. The overlying beds are considered by some of the Russian geologists to be lower Triassic, but others think they are not sufficiently well known to be ascribed either to the upper Permian or the lower Triassic, and designate them Permo-Triassic or PT, and call them provisionally Tartarian.

For two thirds of the distance from Perm to the Volga only the lower Permian beds P_1^b, and Quaternary are seen, unless the deposit at Kerakoulino below Sarapoul be considered Tartarian in accordance with the views of some members of the Russian Geological Survey. M. Stuckenberg, who is the author of L. G., XI, which describes the geology from Perm to Nijni-Novgorod, and was also the leader of this part of the excursion, holds this to be erroneous. According to him the middle Permian (P_2) commences to appear at Tikhia-Gory, and continues to Sentiaki where the upper Permian (or Tartarian) appears and lasts to and beyond Tschistopol. The further localities on the river from here to Laïchew are credited by him only with the middle Permian P_2. For the rest of the Kama's course, these higher beds with Quaternary persist. He states that in the Kama section the lower Permian is represented by but one member, P_1^b, which consists of gray or brownish gray sandstone, interstratified with more or less nearly red or reddish brown clays, often containing calcareous concretions. Very rarely are found remains of conchifers accompanied more frequently by remains of plants. This bed is 70 to 80 inches thick in the sections near Perm,

Ossa, Ochansk, Sarapoul, etc., and disappears finally further down near Elabouga.

The middle stage of the Permian (P_2) is composed of limestones, dolomites and gray clay marls, and contains the organic remains characteristic of the Zechstein of Germany. It crops out in incomplete sections in the banks of the Kama, between its confluence with the Ij and its confluence with the Volga. At Elabouga the bed P_2 is seen lying on the lower stage P_1^b.

The upper stage P_3 or PT is seen between Sarapoul and the nearest confluent of the Kama to the south[9] covering occasionally the middle stage. It consists principally of clays and marls of a variously tinted red, alternating with beds of white, greenish or gray color. Organic remains (conchifers) are very rare.

The post-pliocene deposits which crop out in the banks of the Kama are represented partly by a fluviatile terrace, and partly by sediments deposited in the Caspian basin of this period: or, to be more accurate, in the series of lakes which were in communication with that basin. These deposits crop out between Tchistopol and the mouth of the river, by preference on the left bank. The post-pliocene terrace is composed of yellowish brown clays with which sands are oftentimes associated. The Caspian beds though nearly of the same nature as those of the post-pliocene terrace are more sandy. These beds contain the remains of mollusks still living in the east of Russia. The fresh or brackish water forms are often accompanied by Caspian marine forms. Here and there in the post-pliocene deposits, bones of the Mammoth, and other animals of that epoch are found. Not very long since a tolerably complete skeleton of a young mammoth was discovered on the right bank of the Kama above Laichew. Below this town and near the confluence of the Volga and Kama isolated bones of post-pliocene mammals have frequently been seen.

In that part of the Volga between the Kama and Nijni-Novgorod, and for a considerable distance above and below these points, travellers have invariably been struck by the great difference between the two banks. Except in a few localities where the river is considerably deflected to the left (i. e. E [?]) the right bank presents a continuous succession of escarpments and outcrops of rock in place. The left bank, on the contrary, forms an alluvial valley, which,

[9] M. Stuckenberg says: "Entre Sarapoul et le confluent de la Kama." L. G. XI. 2.

penetrating several kilometers into the interior of the country presents Quaternary terraces in gentle echelons. When the confluents of the Volga on the left bank unite with the major stream, their valleys are merged into vast spaces like lacustrine basins which owe their origin to the impeded flow of the melting snows and the strong floods of spring. At the confluence with the Kama the lacustrine enlargement begins in the Volga, twenty-five kilometers above Laichew and extends south to Spassk and the ruins of the old town of Bolgary. In the months of May and June the waters of the Volga and Kama at this junction occupy a basin so extensive that from a steamboat it is occasionally impossible to see the shores. In these cases the level of the water is 12 to 13 meters above the normal level. But in the month of August the two rivers have returned to their original beds and the water level has attained its minimum. It happens frequently at this season that the steamers seeking the sinuous and constantly changing channels run aground. This shallowness is most annoying toward Nijni-Novgorod and above.

The left bank of the Volga between the Kama and Nijni-Novgorod shows no older rocks. Most frequently only recent sediments are seen. In some rare localities are found post-pliocene deposits, clays and sands of the terraces, and between the mouth of the Kama and Kazan Caspian lacustrine deposits.

The right bank throughout the whole distance is of middle and upper Permian and of Tartarian or Permo-Triassic age. The middle Permian stage, the representative of the German Zechstein, is composed of limestones and dolomites, partly of oolitic structure, with interstratified beds of silex, and more or less considerable deposits or accumulations of Gypsum. This stage, which contains almost everywhere many organic remains characteristic of the German Zechstein, rises from beneath the upper stage between Bogorodskoie (the mouth of the Kama) and Kozlovka (opposite the mouth of the river Ilet and 30 kilometers below the town of Sviajsk). The upper stage (P_3) or the Tartarian (PT) consists principally of different colored (red, pink, white, greenish and greenish gray) marls, accompanied by thin beds of white limestone, variously colored clays, and sandstone. This bed is very little fossiliferous, and contains only some conchifers.[10]

[10] Fifteen years ago the opinion was held by certain Russian geologists that the beds of iridescent marls P_3 or PT were parallel formations with a part of the beds P_2., with passage of the marls into these latter horizontally. Now, thanks to the labors of the Geological Survey and to recent researches of the geologists of Kazan, it is beyond doubt that P_2 and PT are independent stages bedded the one in the other. [L. G., IX, p. 10.]

At the landing place of the village Bogorodskoië, a little above the mouth of the Kama, the following is a section of the right bank.

P_3—Light red and brownish red marl.
P_2—Greenish gray marl.
Gray limestone, finely stratified with brown spots, containing casts of conchifers.
Brown, friable sandstone, with white strata.
Finely stratified gray marl.
Boulders.

The beds, which are hidden by boulders, are shown a short distance below.

P_2—Finely stratified grayish limestone, ...	0·75 m.
Friable sandstone, ...	0·75
Gray marl, ...	0·25
Boulders, ...	2·5

Between the above two outcrops, in a rocky promontory, are shown:

P_2—Finely stratified, gypsiferous limestone, soiling the fingers, ...	0·5 m.
Finely stratified, grayish limestone, with remains of conchifers, ...	2·–
Gray clay marl, interstratified with gypsum, and containing many specimens of *Lingula orientalis*.	0·5
Gray oolitic limestone, abounding in fossils characteristic of the Zechstein, ...	10·5

A limestone analogous to the last crops out immediately at water level at 2–3 wersts above Bogorodskoië.

Near to the landing place at Kozmodémiansk, on the Volga, the following section was made:

P_3 (PT)—Light red marl with greenish and gray beds, ...	15· m.
Light gray sandstone, ...	2·
Reddish brown marl with greenish gray beds,	3·
Brownish gray friable sandstone, ...	1·
Boulders, ...	1·
Boulders beneath which appear a gray marl, .	6·

The right bank of the Volga between Kozmodémiansk and Nijni-Novgorod.—Here are found upper Permian, Mesozoic and Post-

pliocene deposits. The first of these predominate in all the outcrops and are almost always covered by the others. The upper Permian, P_3 or PT, attains a thickness of 100 m. and more. It is developed in an uninterrupted series of marls, sandstones, conglomerates and more rarely limestones.

The predominance in the series of this or that deposit affords a differentiation of the following horizons:

A. Clay and marls with interstratified beds of limestone.
B. Sands and conglomerates with subordinated marls.
C. Marls and sands with subordinated sandstones.
D. Sandstones and sands with subordinated marls.
E. The same rocks with beds of limestones and conglomerates.

In all the sections the horizons B and C are the most definitely and best expressed. The horizon A is in most cases eroded. The lower horizons are most frequently masked by slips and detritus and are not very visible, except near the villages of Issady, Barmina, and Wassilssoursk. The fauna is represented by numerous conchifer mollusks of the group *Anthracosidæ*, especially by the genera *Palæomutela*, *Oligodon* and *Palæoanodonta;* by rare gasteropods *Estheria*, *Palæoniscidæ*, *Ceratodus* and *Stegocephali*. The plant remains are generally badly preserved.

The Jurassic and Volgian deposits cover in separated islets the Permian series of the environs of Issady, Barmina and Wassilssoursk. These are dark gray clays with subordinate beds of sand, conglomerates and limestone. Their ages are referred to the Callovian, Kimmeridgian and Volgian epochs.

The Post-pliocene is represented by yellow lœssoid clays enclosing a few pebbles and crystalline rocks.

Below Issady the Volga valley's right slope forms an enormous curve, in the upper part of which are seen from the steamboat yellow outcrops more frequently of lœssoid clays (Q_1), gray outcrops of the Jura (J) partly hidden by thickets, and below, the outcrops of Permian (Tartarian) rocks (P_3 or PT). The Jura, which is of exceptional interest in this section, is unfortunately less visible to-day than a few years ago, when Sibirtzew, in 1886, established the following sequence:

(1) Yellowish brown lœssoid clay.
(2) Dark green sandstone with *Aucella mosquensis* of the Volgian horizon (horizon of *Oxynoticeras catenulatum*).
(3) Black bituminous clay without fossils.

(4) Brownish and yellow clay with a bed of limestone (*Oppelia, Perisphinctes*) determined as a zone of *Hoplites* of the Kimmeridgian.

(5) Sandstone of the lower Callovian and conglomerates with *Cosmoceras Goweri, Cadoceras sublæve,* some forms of *Perisphinctes,* accompanied by *Belemnites, Protocardium, Concinnum,* etc.

(6) Gray clays of the gypsiferous lower Callovian, with prints of *Cadoceras.*

(7) Variously colored marls.

(8) Sands and conglomerates with subordinate marls.

(9) Marls interstratified with limestone.

Issady—Nijni-Novgorod.—Among the outcrops on the old right bank, between the landing places of Issady and Nijni-Novgorod, that below Takinsky deserves especial attention, on account of the appearance of the middle and lower horizons of the marly and sandy Permian rocks, notably the series C_1—marly, D—arenaceous marly, E—marly calcareous.

Nijni-Novgorod.—The city is situated on the high and rather steep right slope of the valley, at the confluence of the Volga with the Oka. On the side of the Volga the slope is partly covered with vegetation, partly with buildings, débris, etc. On the Oka side, on the contrary, fine outcrops permit one to see the structure. Two sections are especially characteristic: the first in the banks of the river Yarilo and the other in the ravine near the camp. The first of these sections is seen near the town opposite the steamboat landing of the Oka, in the great ravine of the Yarilo. The section is as follows:

Post-pliocene, yellow lœssoid, sandy argillaceous clay with a very few marly and a few pebble inclusions.

Permian deposits:

A. Marls imperfectly visible in the right slope.

B. Thick bed of sand, sandstones and conglomerates, with subordinate beds of marls. In the left slope the conglomerate of this horizon contains casts of *Palæomutela.*

C. Thick deposits of variously colored marls interstratified with limestones and many beds of sands and sandstones.

Between the upper layers of this bed there is a thin layer of much disintegrated limestone, containing numerous perfectly preserved shells of various *Anthracosidæ,* especially the groups *Palæomutela keyserlingi, Palæoanodonta fischeri* and *Oligodon.* These

same shells are encountered in other beds of limestones and marls, but very badly preserved and in the form of interior casts.

The lower horizons of the Permian deposits appear more distinctly above and below in the ravine. There is visible 30 or 40 meters below the place just described, between variously colored marls, a bed of sandstone and conglomerate in which are encountered the shells and other remains of ganoids, accompanied by casts of conchifers.

From the plateau the view extends far into the valleys of the Volga and Oka and over the terraces of the left slope of the valley.

From Nijni-Novgorod to Moscow. — The railway from Nijni-Novgorod to Moscow, following up the valley of the Klinzma crosses a band of Permian, and later a long and narrow belt of middle Carbonic limestones, following which it again crosses a narrow band of Permian before reaching the Jura-Cretaceous or Volgian on which it continues all the way to the ancient capital.

The Oural excursion was thus concluded after having passed rapidly over 3,750 kilometers, (2,330 miles) of the most important of the geological horizons in south and east European Russia, including a long and typical part of the Volga, nearly a sixth of the entire length of the Oural Mountains both in Siberia and in Europe, and more than half the length of the river Kama.

The insight which this journey affords to the geological structure of central European and Asiatic Russia could not have been obtained in any other investigation of equal length and time, nor in any other less well prepared, illustrated, and conducted.[11]

[11] The sincere thanks of all students of geology are due to his Imperial Majesty, the Tsar, for the boundless liberality he extended to the foreign visitors; to the Russian geologists for the enormous and intelligently directed labor they devoted to the preparation of the means for demonstrating their vast and difficult problems to hundreds of strangers ignorant of their customs and language; to their energy and pluck in carrying out their programme without a mishap; and to the hospitality and kindness of all classes of their countrymen, who made the long journey a continuous succession of pleasurable experiences.